WORLD PETROLEUM

NEW YORK AND LONDON

MAY 1938

LAFITTE—WORLD'S DEEPEST FIELD

WORLD'S DEEPEST WELLS

MODERN TREND IN DRILLING EQUIPMENT

OFF SHORE DRILLING

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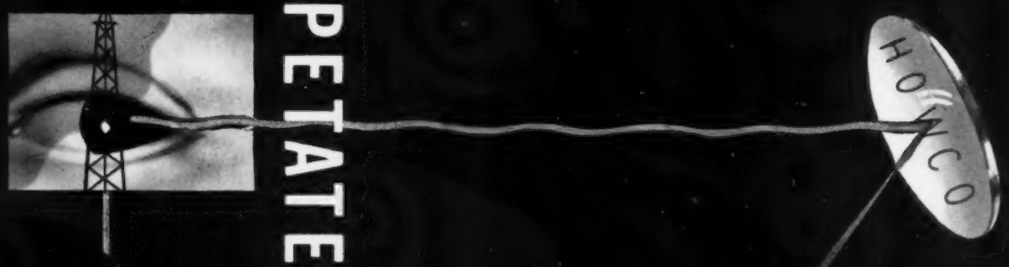

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HOW TO TEST IT?
HOW TO SET CASING ACCURATELY?
AND, ABOVE ALL —
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★ ★ ★

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This was done not only on ONE well but was a standardized program on 56 completed wells, without a failure! ★ ★ ★

We pay tribute to the CONTINENTAL OIL COMPANY for meeting this challenge, and appreciate the opportunity of assisting them.

May we assist you too?

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WORLD PETROLEUM

RUSSELL PALMER
Publisher

E. W. Mayo
Editor

T. Orchard Lisle
Executive Editor

E. W. Mayo, Jr.
Managing Editor

S. J. Gallay
Advertising Manager

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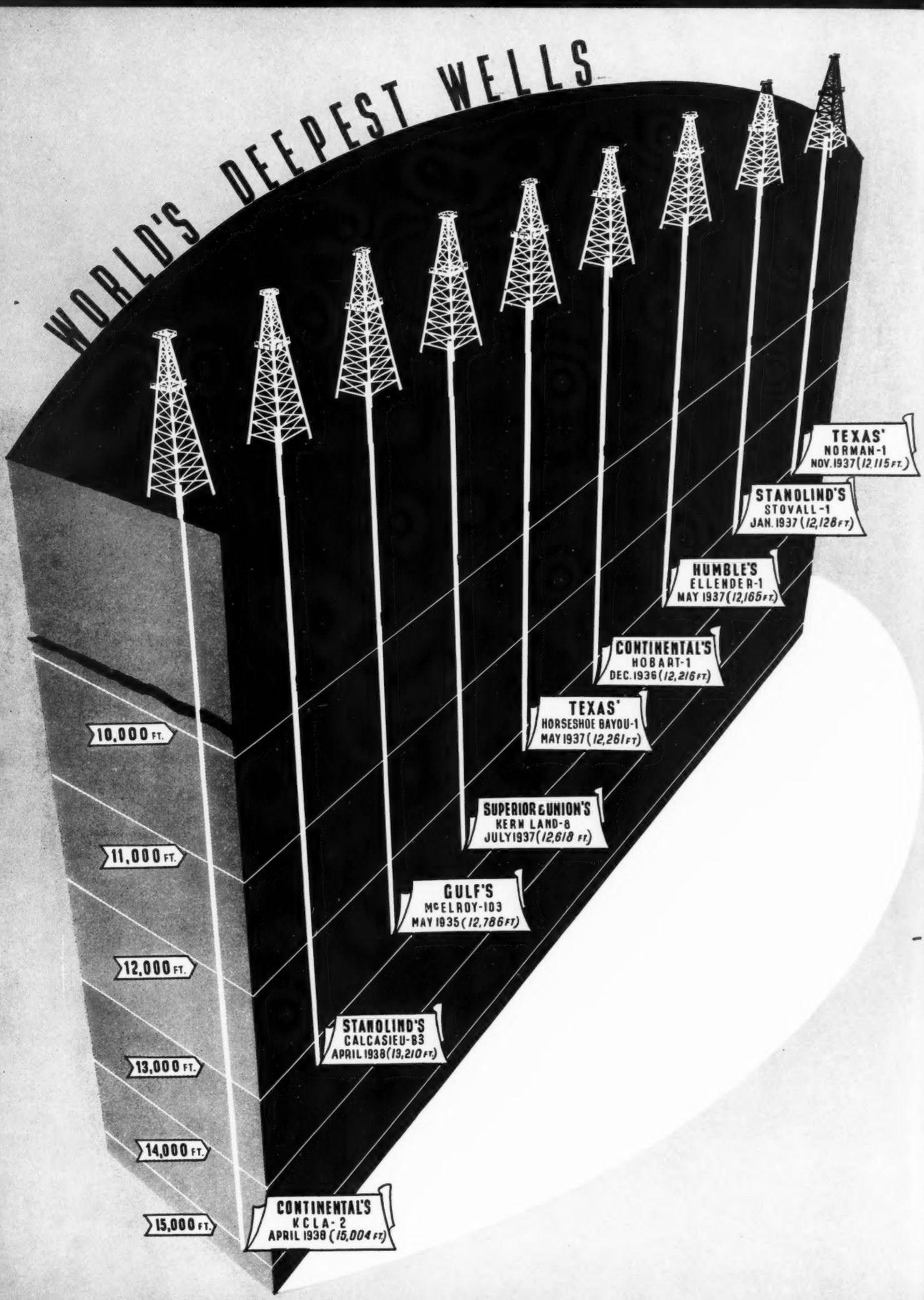
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EDITORIAL

INTERSTATE COMPACT ON TRIAL

IN the abstract almost all oil producers admit the desirability, even the necessity, of the proration of oil production. In concrete, as affecting his own operations, however, the individual producer can provide any number of convincing reasons why the pool in which he is immediately interested should be given a higher allowable.

A similar situation prevails as between the various states. Texas operators assert bitterly that their state is "carrying the umbrella" for other producing areas. California, with no legal authority to control output, declares that she is doing the best she can under the voluntary limitation of output. Governor Huxman of Kansas holds the spectre of federal control before the members of the Interstate Compact unless Kansas gets a larger share of the market.

These are familiar ebullitions of human nature but they do illustrate the difficulties involved in attempting to hold the scale seven between different fields within a state and between different states by a loose voluntary organization such as the Interstate Compact. These difficulties are multiplied at a time when heavy stocks and a more or less static demand counsel a reduction rather than an increase in output.

Facts, however, are stubborn things and the facts are that current stocks of motor fuel are dangerously large and that they are not being reduced appreciably because production since the first of the year has been just about equal to current demand. Joseph E. Pogue and other economists have pointed out specific lines of procedure by which the topheavy supply situation can be gradually relieved during the summer without imposing serious hardship on any single interest. Such a course would be far preferable to overproduction with a consequent shattering of crude prices.

Federal control would prove no remedy for the particular inequalities against which complaint is being made. Federal policy, as shown by the treatment accorded other industries, is based upon past records of production and the maintenance of an "as is" condition, modified by political exigencies that may arise from time to time. Such a program is ill-fitted to an industry so volatile as the oil business. It probably is true that those who are voicing the threat of federal control are not really in favor of it but are using it to win consideration for their own demands.

One fact to be kept in mind, however, is that nothing else could so certainly lead to federal intervention as the breakdown of state and interstate regulation. This undoubtedly is well known to those who have the responsibility of making the present system work. They will be well advised if they exert every effort to strengthen it even at some sacrifice on the part of local interests.

HAS CONFISCATION HELPED MEXICO?

IN the six weeks that have elapsed since the Mexican government confiscated the properties of foreign-owned oil companies, few signs have appeared of progress toward a settlement of the issues raised by its extraordinary action. With the exception of native workers, officials and employees of the companies have been driven out. The properties themselves are in the hands of the syndicalists but in large part are inactive. The governments of the United States and Great Britain have filed protests to which the Cardenas government has replied maintaining the validity of its act of expropriation. Diplomatically the situation, therefore, is one of deadlock, temporarily at

least. An official organization known as the National Petroleum Export Corporation has been trying, apparently with little success, to find purchasers for the confiscated oil which is overflowing storage tanks and in some localities is said to have been burned because of lack of storage.

Meanwhile it has become increasingly clear, as has been pointed out frequently in these pages, that the movement which culminated in the physical seizure of the oil properties was primarily political. Had it been an ordinary labor controversy involving wages, hours, and terms of employment, it would have been settled long ago to the satisfaction of the employees themselves since they have been for years the highest paid class of workers in the country and enjoyed privileges shared by no other similar group. Repeatedly during the negotiations and investigations of the past year and a half the oil companies have offered progressive increases, both of wages and privileges. A week before the issuance of the expropriation decree the companies offered to accept the labor board award of increased wages and allowances amounting to 26,000,000 pesos annually.

To have accepted these offers would have defeated the real purpose of those who were manipulating the situation toward complete elimination of the actual owners and developers of the properties. Step by step the net was drawn until the companies were faced by the choice between having the administration of their businesses taken over by the professional exploiters of labor who controlled the unions or having their properties confiscated by the government. The ultimate result would have been the same in either case.

Not only have the instigators of the plot succeeded in getting the oil industry into their hands but they appear to have gained complete control of the government itself. President Cardenas, judged by his recent speeches and actions, has put revolution ahead of reform. By permitting the arming of the syndicalists he has taken a step which in Russia, Spain and other countries has led to disorder and bloodshed. It is to be hoped that Mexico will prove the charmed exception to this rule.

The oil industry itself is in a state of disruption which has resulted inevitably from the sudden removal of its trained personnel and technical directors. Production has fallen to less than one-quarter of the normal output. Withdrawal of shipping, interrupting the export movement of crude and swamping storage, has led to shutdowns in many fields. Reports are current of trouble in Poza Rica from water encroachment. Many refineries are inactive. Deterioration of both field and manufacturing properties is imposing losses that will mount higher as time goes on. Despite the cessation of exports, a shortage of motor fuel is reported in certain parts of the country due to the inadequacy of transport facilities. As the available supply of blending material runs out, the quality of the fuel dispensed is bound to deteriorate.

Among the first to suffer from the upset to the industry are the oil workers themselves in whose name the whole gigantic farce has been conducted. Many of them have lost their employment. The others are no longer entitled to the social benefits and special allowances and privileges which they received from their former employers and are uncertain how long they will continue to receive their present pay. Promises were held out that the industry would be turned over to them but they find now that the fine offices and the lucrative positions are filled with those who have as little knowledge as themselves of business operations, perhaps even less, but who have a stronger political pull. They are disillusioned, dissatisfied, but helpless.

The one department in which the plans of the group now in actual control of Mexican affairs are functioning perfectly is that of propaganda. The skill with which this activity is being directed as well as its character indicates the handiwork of propagandists Moscow-trained in the school of the Third Internationale. At the present time the united popular support of which President Cardenas boasts is due largely to the adroit means by which the people of Mexico have been convinced that the executive head of the government of the United States is in full sympathy with Mexico's seizure of American and British owned properties. Some offhand remarks by President Roosevelt as to limitations which he thought should apply to the remuneration of oil companies for their properties gave the cue. An ingeniously worded message to the President from members of the Mexican Chamber of Deputies and his perfunctorily polite reply supplied the material that has been circulated from end to end of Mexico as evidence that the Chief Executive of the United States has aligned himself with the confiscators.

Aside from the breakdown in the general administration of Mexican affairs that is becoming daily more evident the factor that has been most influential in preventing the Mexican authorities from deriving their expected profits from the illegal seizure of the oil properties has been the unwillingness of outside users of petroleum to buy Mexican oil. As pointed out in these pages last month, a refusal by the rest of the world to participate in the exploitation of the seized properties would prevent the realization of the advantages anticipated from the act of confiscation. It is interesting to note that the British authorities have made it clear that they will not countenance trafficking in Mexican oil on the part of their nationals.

There is a natural unwillingness on the part of honest men to deal in stolen goods. Those who are willing to handle such merchandise expect to obtain it much below the going price. Unless Mexico can sell oil, the mere possession of it is of little practical advantage. While purchasers may be found, the terms they have to offer are likely to be disappointing. It begins to be evident that for the welfare of her own workers, the interests of her consumers and the fiscal position of the government itself, Mexico has been seriously injured by the act of confiscation, to say nothing of her loss of standing among the nations of the world.

BRAZIL Nationalizes Petroleum Industry

Decision to Build Refineries Will Change Character of Imports From Products to Crude and Will Adversely Affeet Export Trade of the United States—National Petroleum Council to Have Broad Powers.

ANNOUNCEMENT in Rio de Janeiro on April 26 that President Getulio Vargas had issued a decree nationalizing the petroleum industry was widely interpreted in other countries as meaning that Brazil was following the example of Mexico in taking over the refining of petroleum and the distribution of its products. Coming so soon after the action of the Mexican government in seizing the properties of internationally owned oil companies, this was perhaps a natural conclusion but from such information as has been given out, it appears that Brazil's undertaking is entirely different from that on which Mexico has embarked.

Moreover, Brazil's decision to nationalize the petroleum trade is no sudden determination. Some two years ago a commission appointed to study the subject made certain recommendations leading in that direction and for several years past Brazil's tariff has been so adjusted as to encourage the building of refineries within the country. The import duty on gasoline, expressed in equivalent terms of United States currency, has been nearly eight cents per gallon; on kerosene, about five cents per gallon; on fuel oil, three-quarters of a cent, and on crude oil, two-tenths of a cent.

As is well known, Brazil has no indigenous petroleum resources, at least none that have been developed thus far, although the government has offered special inducements for exploration and there has been some drilling activity for the past several years. Until the present tariff was adopted there was no refining industry in the country. Its entire requirements of gasoline, kerosene, lubricating oil and fuel oil were supplied by importation, mostly through marketing organizations maintained by large international companies, such as Standard of New Jersey, Socony-Vacuum, Shell, Texas and Atlantic Refining.

With the adoption of tariff rates that provided a subsidy of roundly four cents per gallon on kerosene, and over seven cents on gasoline refined within the country, the development of a Brazilian refining industry began. The first plants erected were small affairs and their operations were confined to the production of kerosene from fuel oil by simple distillation. The product was inferior in quality to the standard brands sold by the large marketing companies but with the high margin provided by the tariff these distillers were able to operate at a profit.

The first refinery capable of turning out a full line of products was built in 1935 at Uruguayanna in Rio Grande do Sul, the southernmost state in Brazil. In 1937 a second complete plant, known as Ipiranga S. A., was completed at Rio Grande and Standard Oil of New Jersey, through its Brazilian subsidiary, Standard Oil Company of Brazil, began the erection of an up-to-date refinery at Sao Paulo. This plant was about 80 percent completed at the time when the recent order of the President suspended the work of construction. In the normal course of events it would have been ready for operation in July. What will happen to it probably will depend to some extent upon the interpretation put upon the decree by the commissioners who were appointed to administer it.

The new law is an expression of the intense nationalism which has developed in Brazil in recent years under the leadership of President Vargas and the army officers who are his close advisors. It provides for a National Petroleum Council to be appointed by the President. This body will supervise all operations of the petroleum industry, will regulate imports, refining, distribution and marketing, and will determine the prices at which petroleum products may be sold. It also will administer the law regarding exploration and drilling within the country.

The object in view admittedly is to bring about the creation of a refining industry under the control of Brazilians which will be capable of supplying the country's needs in the way of petroleum products, and to carry on a systematic search for oil which, if found, likewise will be kept under the control of Brazilian interests. With a tariff working strongly in their favor, Brazilian capitalists probably will encounter no difficulty in finding means of constructing refining plants and it is reported that projects already have been formed for two such plants, one to be located in Sao Paulo and another in a more northerly port. Unless, or until, oil is located at some point within the country from which it can be economically supplied to such plants, they will have to rely on imported crude and for this reason it is unlikely that Brazil will adopt a policy that might antagonize the countries from which it can draw crude supplies advantageously.

IMPORTS OF PETROLEUM PRODUCTS INTO BRAZIL

Statistics in Metric Tons

Gasoline	1935	1936
United States	129,221	139,664
Netherlands West Indies	50,435	91,902
Peru	67,265	72,225
Mexico	28,427	19,746
Others	1,865	980
Total	277,213	324,517

Kerosene	1935	1936
United States	67,524	78,680
Mexico	16,588	11,919
Peru	8,120	.....
Others	1,657	1,422
Total	93,889	92,021

Fuel Oil	1935	1936
Netherlands West Indies	290,114	481,227
Mexico	125,976	36,956
United States	12,080	6,394
Uruguay	8,227	8,108
Others	315	.....
Total	436,712	532,685

One probable effect of the newly adopted program will be to decrease the share of the Brazilian petroleum trade held by the United States. In 1926 the latter country supplied 77 percent of Brazil's requirements of petroleum products but by 1935 this had dropped to 55 percent. If the bulk of imports shifts to crude there are other countries better situated to supply it than the United States, and this once flourishing branch of United States export trade may be extinguished. The small importations of crude received heretofore have come from Argentina and from the west coast of South America.

Owing to the fact that the United States is the largest consumer of Brazilian coffee and imports huge quantities annually, the balance of trade between the two countries has been steadily and greatly in Brazil's favor. Sales of petroleum products formed a leading item in exports from the United States and the loss of this business will further increase the discrepancy in the trade balance between the two countries. In 1937 the value of all exports from the United States to Brazil was $68,631,000 while products imported to the United

(Continued on page 81)

IRISH Refining Monopoly Remains Financial Enigma

By Alec. H. Day

THE MYSTERY of Irish National Refineries continues to be almost as obscure as it has been from the beginning, although a bit of light was thrown upon it indirectly through statements made at the annual meeting of London and Thames Haven Oil Wharves by Chairman T. C. J. Burgess. His reference to the subject was confined, however, to the relation to the Irish project of the company whose shareholders he was addressing. It does not fully explain just where the control of Irish National Refineries lies or exactly what its financial plans are.

At the time when the authorities of Eire granted a refining monopoly to Irish National Refineries Ltd., it was understood that the company was controlled by Parent Petroleum Interests and that the dominating factors in that concern were W. R. Davis, Lord Inverforth and Mr. Burgess, the holding of the latter representing his personal investment and not that of London and Thames Haven.

On the record Irish National Refineries, the company formed to supply the petroleum requirements of the Irish Free State under license from the Free State government, has an authorized capital of £1,000,000. Of this, £10,000 has been issued, and is held by Liffey Trust, owned by Thos. C. J. Burgess, and his associates. It is obvious, therefore, that the construction of the Dublin refinery will require considerable finance in the immediate future. A question that interests financial circles is whether this financing is to be provided by London and Thames Haven through Parent Petroleum Interests.

According to information which was accepted by London financial circles as reliable, the control of the Parent Corporation formerly rested with Mr. Burgess and Lord Inverforth through a voting trust. Later it was stated by a close associate of Mr. Davis that the latter had acquired 60 percent of the stock and would control the policy of the company henceforth. Meanwhile, little progress was made toward the construction of the Irish refining plant and it was rumored that Messrs. Davis and Burgess were not in entire agreement as to the refining monopoly, the former believing that it was open to many objections as a purely business venture, while the latter retained his original enthusiasm for it. No authoritative statement ever was issued by the parties most directly concerned and the reports are mentioned only for their possible bearing on the remarks by Mr. Burgess at the London and Thames Haven meeting. Referring to the financing of the Irish project, he said:

"We entered into arrangements with Parent Petroleum Interests which satisfactorily settled the question of finance outside of this company, but I took the precaution of retaining an option to reassume control . . . . The arrangement for finance by one of our allies still remains good, but carries the control with it.

"The directors propose now to secure that the permanent control is vested more closely in the Thames Haven Company, and they unhesitatingly ask for your support in this connection."

This part of the speech led up to a reference to the proposal to increase the directors' borrowing powers from £1,300,000 to £2,500,000. The increase was agreed to by shareholders, and is evidently to be used to raise further funds to pay for plant for Irish National Refineries.

The part which Parent Petroleum Interests is playing in the scheme still presents an enigma. The London and Thames Haven chairman expressed the belief that this company's investments in oil and refining in Mexico, the United States, and elsewhere were so well spread and of such a nature that should any of the varied interests fail, its remaining interests were quite capable of meeting its capital requirements and at the same time providing, in due course, a fair return on its capital.

Mr. Burgess gave no particulars of Thames Haven's dealings with Parent Petroleum Interests, and it is, unfortunately, impossible to fill in many gaps in available information from the details filed by the latter company in the Company Records Office. Capital is £4,500,000 in £1 shares, of which £4,472,613 has been issued and paid up. The latest return of shareholders, dated July 28, 1937, is as follows:

Lloyds Bank (30, Threadneedle Street, E.C.) Nominees	1,154,568
National Bank of Scotland (London Nominees)	577,285
Lloyds Bank (Colonial and Foreign) Nominees	1,127,183
Gibraltar Securities (74, Main Street, Gibraltar)	1,613,575
Two shareholders with one share each	2
	4,472,613

Shareholdings have been disguised by their transfer to various nominee companies and the real holders' names do not appear. Their identity is suggested by the fact that Mr. Burgess, Lord Inverforth and W. R. Davis remain the three directors.

An item of some interest in the recent record of the company is a charge for £100,000 on a debt of £296,483 owing to the company by Irish National Refineries, created on February 4 last in favor of London and Thames Haven Oil Wharves.

It seems from this disclosure that the latter has been financing the Irish National Refineries indirectly, through Parent Petroleum. In addition, it may have been raising bank overdrafts to take up additional shares in Parent Petroleum, thereby putting that concern in funds for financing the Irish development.

Aside from its purpose as a possible channel for finance, Parent Petroleum Interests is presumably the source from which crude oil is to be derived for the Irish National refineries. Actual plans for obtaining the crude are as obscure as the finances of the group, but possibly Mr. Davis' activities in Mexico may provide the answer to this important question.

Meanwhile, the position of Thames Haven has not changed for the better during the past year, in spite of the maintenance of 1937 earnings at around their former satisfactory level. Although the company has contracted a big bank overdraft, the cash holding at the end of last year was no more than £13,434, a small amount for a company with a capital of £1,300,000.

Doubtless the directors anticipate the correction of the cash position by use of the new borrowing powers now in their hands, although borrowing by the company in London may be more difficult now than it was last year.

BRITISH GAS WELL

NATURAL GAS has been struck by D'Arcy Exploration Company Ltd. (Anglo-Iranian) in its Cousland No. 1 test, seven miles southeast of Edinburgh, Scotland. The gas was encountered in sandstones of the oil shale group extending from 1,582 ft. to 1,640 ft. Tests of the upper and lower sections of this zone have proven an initial daily production of at least 4,000,000 cu. ft. The intermediate portion, potentially productive, is untested. The well has reached 1,652 ft. and will be carried to the base of the oil shale group of the Lower Carboniferous, which should be encountered at about 3,000 ft.

NEW RECORDS Set for Deep Drilling and Production

Extraordinary Accomplishment of Past Year in Carrying Drill to Depths Never Before Reached Derives Added Importance from Substantial Production Obtained

REMARKABLE records in deep drilling have been established during the past year and especially during the past few months. Not only has the drill penetrated to far greater depths than ever before, but a large number of wells have been completed in various areas at depths from 11,000 to 15,000 ft. More important still, from the practical side, a large proportion of these exceptionally deep wells have proved to be producers, though not all from their extreme depths.

Formerly the deepest wells drilled were dry holes or yielded showings insufficient for commercial operation. Within the past twelve months, however, a round dozen wells of 11,000 ft. or over have been completed as commercial producers in different parts of the United States and a number of others now drilling below 10,000 ft. give encouraging indications. While the deep dry holes that have been put down yielded valuable geological information, the actual producers recently brought in supply convincing evidence of the presence of oil in deep lying formations and indicate the possibility of great additions to the potential reserves of the fields in which they are located.

Among the wells of extraordinary depth the one that has loomed largest in public interest in recent months has been the Continental Oil Company's KCL A-2 located five miles west of Wasco in the San Joaquin Valley of California. Not only did this remarkable well exceed by more than 2,000 ft. the greatest depth that had been reached up to the time of its completion but in tests of formations previously penetrated it showed a high rate of production from the 13,000 ft. level, thereby attaining the double record of being both the deepest well and the world's deepest producer.

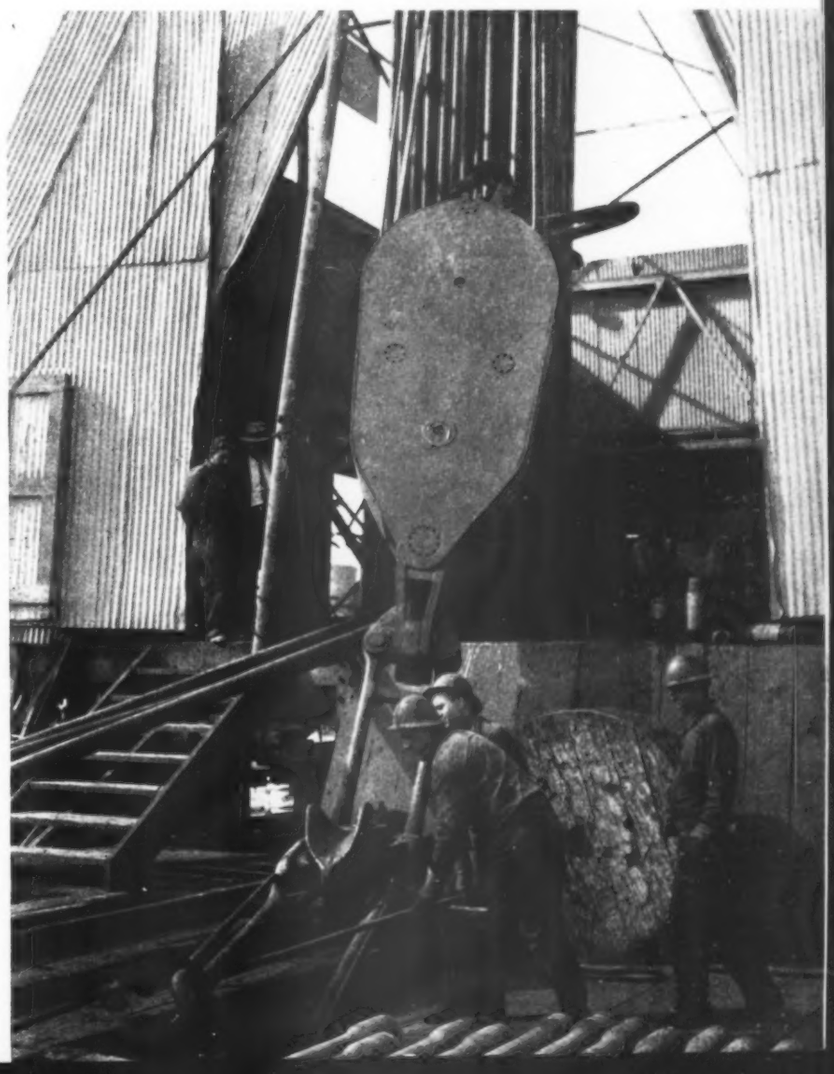
Continental was satisfied and everyone else impressed when the well, designed to test sands at 9,500 ft. in the valley, reached the world's record depth of 15,004 ft. in April of this year. Much valuable geological data had been obtained; equipment had been tested and the way opened for redesign of certain parts for deep drilling. It is one of the world's straightest holes.

Before abandoning the hole, showings encountered on the way down were tested. Plugged back to 13,175 ft. and swabbed, fluid level rose rapidly and finally produced mud and water at the well head. Within a few hours the flow had changed to oil and subsequent tests established the existence of a productive structure between 13,092 and 13,175 ft. Some 3,000 bbl. per day through ¾ in. bean of 37.1 deg. oil and 660,000 cu. ft. of gas is the initial production. Tubing pressure was 320 lbs. and casing pressure was 50 lbs. The well is producing from a Miocene formation. Its location marks a new departure for the San Joaquin Basin in that it is several miles out from the shoreline: heretofore drilling was confined to the margins of the basin, although of late there has been a tendency to move farther out toward the center, a development which will occasion more deep drilling.

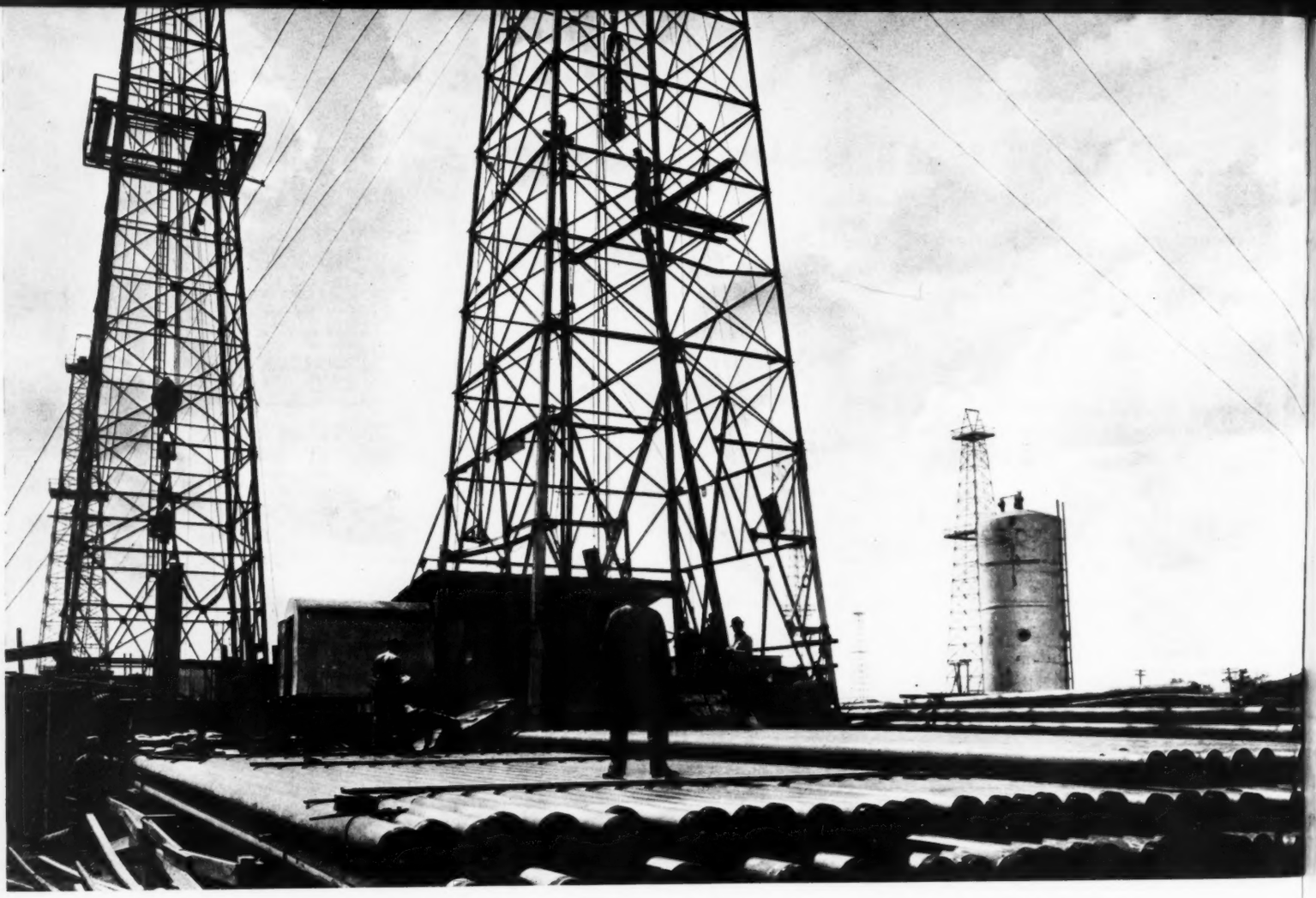
Geophysical exploration with seismograph determined the location of the well. It was spudded in June of 1937 and a depth of 9,500 ft. was anticipated. The rig was provided with a 122 ft. derrick, medium size engine, draw works and pumps and four 100 h.p. 250 lb. pressure boilers with a separately fired superheater. A water well 185 ft. deep furnished over 7,000,000 gallons of water to the gas fired boilers. Heaving shale was encountered down to 5,000 ft. After setting 497 ft. of 16 in. casing the hole was drilled through shale with four way bits. At 5,512 ft. a 10¾ in. 55.8 lb. seamless string was landed. This depth was reached in 13 days. At the end of 120 days a depth of 11,584 ft. had been reached rock bits having been used all the way down except when taking cores. At this depth the

GENERALIZED LOG OF THE FORMATIONS

Age	Character	Depth
Pliocene	Soft sands and silts	0- 2820
	Shale	2820- 4380
	Bluish gray shales and silty shales	4380- 8440
Miocene	Grayish brown shales	8440- 9527
	Cherry brown shales showings of oil and gas	9527- 9620
	Hard brown shales	9620-11581
	Hard sand	11581-12175
	Sands and hard brown shales	12175-12715
	Oil showing at 12,600	
	Hard dark brown shale	12715-13110
	Hard dark brown shale, few thin streaks hard sand	13110-13130
	Oil showing at 13,130	
	Hard sand, streaks dark shale	13130-13645
	Dark shale, streaks hard sand	13645-13820
	Hard fine sand, siltstone	13820-14010
	Hard dark shale	14010



Current California drilling practice has a new floor arrangement, with the side of the derrick opposite the hoist wide open, although the well shown is not an underfloor drive rig.



Pipe rack at Barnsdall Oil Company's Gutrie No. 1 well, Oklahoma City—courtesy of A. O. Smith Corporation.

bit stuck and 44 days were lost. The world's longest string of casing was landed at 11,573 ft. and cemented with 800 sacks of high temperature cement. Eleven days were lost when the formation tester stuck and three more days were lost making a production test. Finally, 285 days after spudding the world's record depth of 15,004 ft. was reached.

Another significant deep well completion in California is Kettleman North Dome Association's 418-J completed to a depth of 11,746 ft. in December last, which flowed 1,450 bbl. per day on initial test. In the Rio Bravo section Kernco 1-34 of Union Oil Company completed in November last produced at the rate of 2,500 bbl. daily from 11,302 ft. Several other deep tests in this area have encountered producing sands below the 11,000 ft. level. Important additions to California's available oil resources are indicated by these discoveries. The rapidity with which exploration to greater depths has been proceeding in California is indicated by the fact that Tide Water Associated's McGonigle 12 in the Ventura Ave. field was hailed as the deepest producer in the world when brought in early in 1937 at 10,569 ft. Although not a producer, the deepest well drilled in California prior to the KCL A-2 was the Kern Land 8 of Superior Oil Company and Union Oil Company which ended in a dry hole after at 12,268 ft. in July 1937.

While California retains the record of the world's deepest well, Louisiana has come to the forefront during the year as possessing the deepest important field with many deep producers along the Gulf Coast and inland waters in the southern part of the state. In the Lafitte field, which is the subject of a special article on other pages, wells of 11,000-12,000 ft. depths predominate and during the past year southern Louisiana has contributed to the world's deep well picture half a dozen wells exceeding 12,000 ft. in depth. It is significant that of the wells drilled to 10,000 ft. or more in Louisiana nearly all are substantial producers, indicating extensive deep deposits.

One of the outstanding deep wells in Louisiana is that of the Stanolind Oil and Gas Co. at South Elton in Jefferson Davis Parish, approximately 12 miles north of Jennings, known as Calcasieu National Bank B-3. This well, while not completed, reached a total depth of 13,210 ft. on April 6, 1938, making it the deepest hole in the world with the exception of Continental's KCL A-2. The entire time from the spudding in of this well to the date when its extreme depth was reached was only 131 days. The time required to drill the last 3,210 ft. of hole was 45 days, an average daily footage of 71.3 ft. Density of mud used while drilling below the 9⅝ in. casing set at 8,560 ft. was approximately 15 lbs. per gallon.

After reaching the depth of 13,210 ft. the well was plugged back to 9,223 ft. where a completion attempt is being made.

Another interesting well drilled by Stanolind was the Fred Stovall No. 1 in Vermillion Parish, Louisiana, which was abandoned at 12,128 ft. A remarkable record established by this well was the drill ng of 10,144 ft. of open hole below the surface cas'ng. The size of this open hole ranged from 12½ in. to 11 in. which also was an unusual feature. Mud weights carried during the drilling were from 11 to 12 lbs.

Ellender No. 1 of Humble Oil and Refining Co. in Terrebonne Parish, South Louisiana attracted widespread attention as the world's deepest producing well at the time when it was brought in, May, 1937.

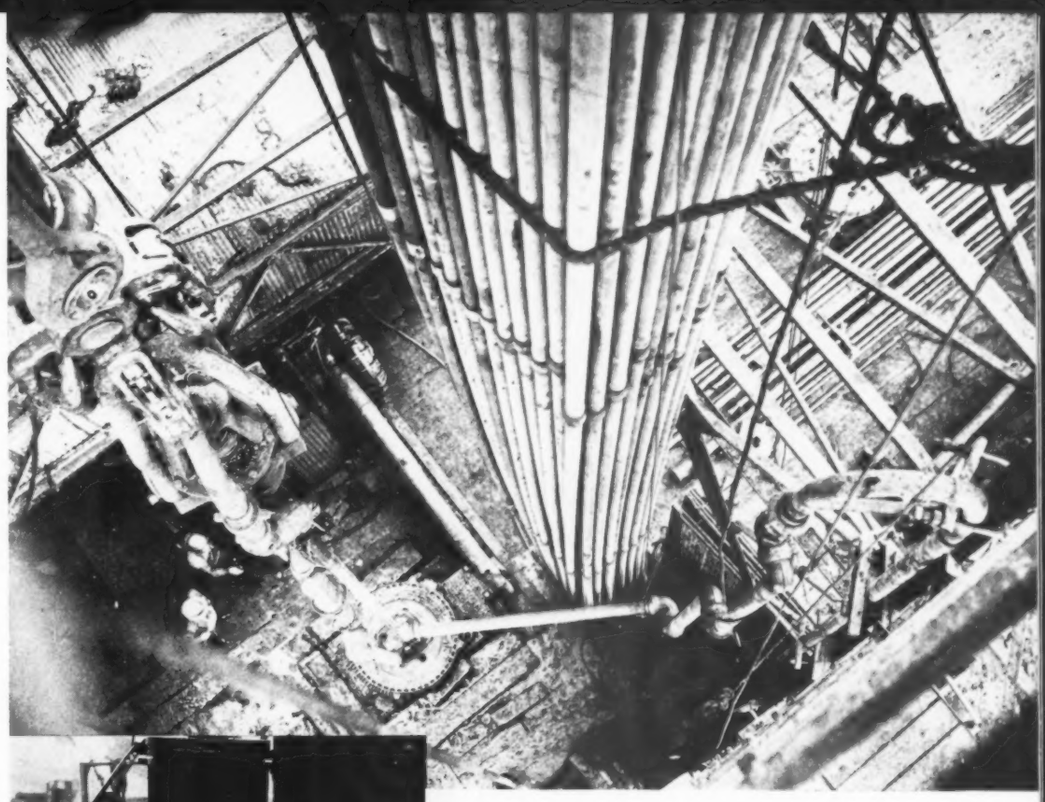
The well reached a depth of 12,165 ft. and

flowed at the rate of 1,000 bbl. daily. It carried records for the longest string of 9⅝ in. casing (8735 ft.) ever run and for the deepest wire line coring job ever attempted. The well is now producing from 10,525 ft.

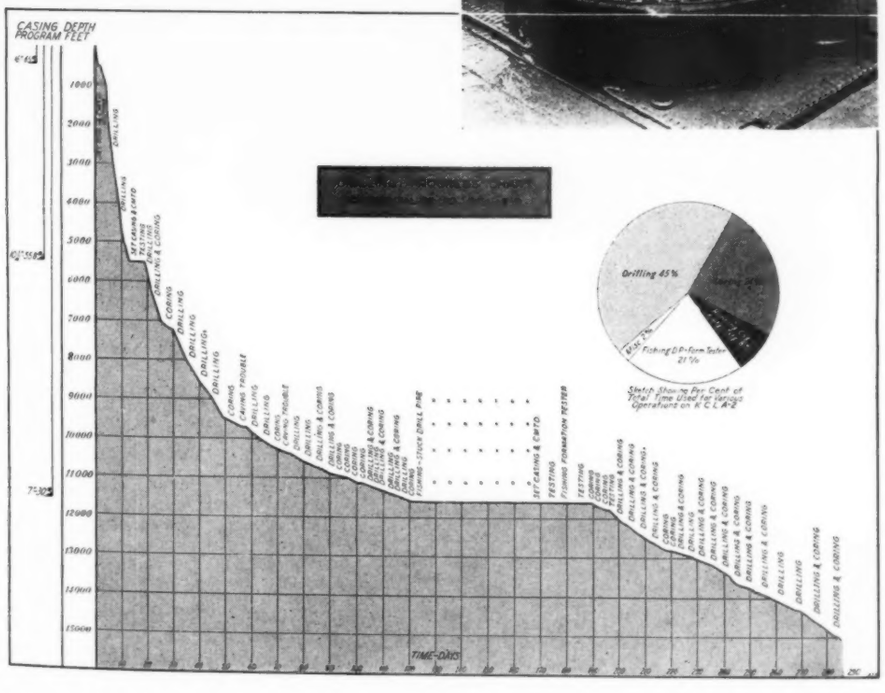
Two wells drilled in Vermillion Parish, Louisiana, by Continental Oil Co. reached depths of 12,216 and 11,909 ft. respectively. These were Hebert No. 1 and Brookshire No. 1. Both were completed as producers by plugging back and perforating casing at 7,884-7,897 ft.

By virtue of the deep zones which it has tapped in Southern Louisiana, The Texas Company now holds the record of having drilled more wells to depths of 11,000 ft. or more than any other company and likewise of having more of these wells with production either from their extreme depths or from intermediate levels.

While no wells outside the United States have matched the depths attained in California and Louisiana, two wells set new records during the past year. The first of these was Zeloi 4 of Anglo-Iranian Oil Co. which reached a depth of 11,190 ft. in May 1937. The second was Kinsui No. 32 of Nippon Oil Co. in Formosa on which drilling was temporarily suspended at the end of 1937 when a depth of 11,502 ft. had been reached. Kinsui No. 32 is not completed one month's statistics are outdated by the



Rig on Continental's KCL A-2—tubing in the derrick was used to test a showing of oil at 9,500 ft.


CASING DEPTH PROGRAM FEET
Drilling 45%
Fishing DP-Form Tester 21%
Sketch Showing Per Cent of Total Time Used for Various Operations on K.C.L. A-2
TIME-DAYS

and probably will be sunk still deeper. The thoroughness with which the progress of this well is being studied is indicative of the extreme care exercised by the Japanese to determine the possibility of increasing their domestic crude production.

Three years ago the total number of wells that had been drilled to 10,000 ft. or more in the entire world was only 13. Of these not a single one had resulted in commercial production. At present the number of 10,000 ft. wells is growing so rapidly that following month. As of May 1, 1938, it appears according to the most reliable records available that there are 112. In the estimation of the trade the 10,000 ft. well is no longer unusual enough to call for special attention and it is only when the 12,000 ft. depth has been exceeded that the title of deep well is deserved.

The experience of the past year has demonstrated that existing equipment is perfectly capable of drilling to depths of three miles through formations that offer no exceptional obstacles. With increasing weights as depths become greater the handling of these weights becomes one of the principal problems to be dealt with. This, however, presents no insuperable difficulty and undoubtedly new and greater depths will be plumbed in the future as conditions appear to justify such exploration. In reviewing recent progress the most important development appears to be, not the records of extreme depth established, but the development of commercial production from deeper zones than have been previously tapped and the possibilities thereby suggested of highly important additions to the world's oil reserves.

Acknowledgement is made of information and valuable assistance received in the preparation of the preceding article from International Derrick and Equipment Co., Waukesha Motor Co., Schlumberger Well Surveying Corp., Sperry Sun Well Surveying Co., Brodrick and Bascom Rope Company, Link Belt Co., Parkersburg Rig and Reel Co., Green Head Bit and Supply Co., Elliott Core Drilling Co., Westinghouse Electric and Manufacturing Co., Martin Decker Corp., Larkin Packer Co., Gardner-Denver Co., Shaffer Tool Works, Reed Roller Bit Co., Lee C. Moore and Co., and Cameron Iron Works, all of whom furnished equipment on the wells discussed.

LAFITTE — World's Deepest Major Field

By Michel T. Halbouty

Vice-President, Chief Geologist and Petroleum Engineer, Merit Oil Corp. of Texas

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Aerial view showing the centralized facilities due to the impassable marshy ground. The oil barge will be towed out of the field via canals and bayous.

While There Are Now More Than a Hundred 10,000 Ft. Wells, The Texas Company's Lafitte, Here Described by an Accomplished Petroleum Geologist and Engineer, Is the First 10,000 Ft. Field.

"THE WORLD'S Deepest Producing Oil Field," is the title given to the Lafitte Oil Field, located in the southern part of Louisiana, and owned and operated by The Texas Company. Even though there are several individual wells producing elsewhere from a greater depth than any of the wells in the Lafitte Field, there is no individual field with a grouping of deep wells that can compare with the operations or the economic significance of the Lafitte Field. Named after a small settlement which derived its name from the most famous of all buccaneers, Jean Lafitte, this oil field is one of the most picturesque in the entire Louisiana Gulf Coast. The field is located in Jefferson Parish, six miles southeast of the town of Lafitte in Sections 19, 20, 28, 29 and 30—17 South, 24 East. The southern part of Louisiana is geologically characterized by the abrupt dip and increased thickness of the formations, which, in turn, necessitates the drilling of wells to greater depths. In this particular geological trend, in which the Lafitte Field is located, there are more deep producing and drilled wells than in any other area in the world. The Lafitte Field is the largest field in Southern Louisiana, having to date an estimated 3,000 proven acres.

Prior to the drilling of the discovery well, the area was first worked geophysically by the Louisiana Land and Exploration Company which, in turn, assigned the area to The Texas Company, by whom the area was then shot with the reflection

seismograph. A deep seated salt dome structure was evidenced by the geophysical work that was conducted. This led to the drilling of the Bayou St. Dennis No. 1 by The Texas Company, which was the discovery well for the field. This well was completed as a producer on May 16, 1935, at a total depth of 9,572 ft. for a flow of 1,100 bbl. of 34.9 gravity oil on 3/8 in. choke. In the drilling of the discovery well, there were several other sands found besides the one that was finally decided upon for production. The lower sand, which is near the total depth of the well, is the producing sand in this discovery. Five months were required to move in and complete this well, although only 60 days were used in actual drilling time. Canals and other initial operating facilities had to be built before actual moving in and drilling were commenced. An unusual feature of this discovery well was in the setting of only 1,170 ft. of 13 3/8 in. surface pipe, and that no other string of pipe was run in the hole until after all of the coring was completed and the total depth reached. Over 8,400 ft. of open hole remained in place without giving any trouble whatsoever, and such an accomplishment gave assurance that the conditions of the sediments were such as to afford perfect drilling possibilities. Up to date this situation has remained unchanged and the formations have not heaved or given any other trouble which otherwise is so common in deep Gulf Coast well-drilling, all of which made this particular trend in Louisiana one of the most important areas in the entire Texas-Louisiana Gulf Coast. After the completion of the discovery well, it was very evident that the field would be of major economic significance.

DEVELOPMENT

At the end of 1935 there were three wells completed as producers with each well producing 1,088 bbl. per day, or a total daily average for the three wells during 1935 of 3,264 bbl. per day, and from the discovery date to the end of 1935, a total of 644,944 bbl. of oil were produced. These three wells were producing from the same zone, from 9,555 ft. to. to 9,595 ft., and the average net thickness of the producing sand in those three wells is 45 ft. In 1935, the deepest well dug in the field was 9,633 ft.

At the end of 1936 there were seven flowing wells. A new producing horizon was established during the year, making a total of two sands, one from 9,396 ft. to 9,440 ft., and the other being the discovery sand from 9,555 ft. to 9,595 ft. The deepest well drilled at the end of that year was to 9,606 ft. and the field had produced 2,724,454 bbl. during 1936, or a total of 3,369,598 bbl. since its discovery.

In the year 1937 activity in the Lafitte Field reached its peak in the completion of 10 wells as producers and the establishment of three new producing sands, making a total of five producing sands definitely proven as productive at the end of the year 1937.

The first and most important well that was drilled in the field in 1937 and which was completed in January, is The Texas Company's Rigoletts No. 5, which, after attaining a total depth of 10,942 ft., was plugged back and produced from a new sand from 10,030 ft. to 10,110 ft. The well produced 1,636 bbl. per day on a 3/8 in. choke. This was the first commercial producer in the world below 10,000 feet. It required six months for the completion of this well. The 13 3/8 in. casing was set at 1,353 ft. and the 7 5/8 in. string was set at 10,244 ft.

Another new sand was established by The Texas Company's R. C. Milling No. 1, which attained a total depth of 10,040 ft. and was also completed in January for 1,550 bbl. per day on a 3/8 in. choke. A new sand was cored from 9,912 ft. to 10,010 ft.; this was the second 10,000 ft. commercial producer in the world and the Lafitte Field carried the distinction of drilling successively the first two 10,000 ft. commercial oil producers.

The third well of distinction during the year was The Texas Company's Rigoletts No. 7 which established the third new producing sand, increasing the total to five producing horizons for the entire field, when it flowed 1,382 bbl. per day on a 3/8 in. choke from sand at 10,210 ft. to 10,240 ft. The well was originally drilled to a total depth of 10,406 ft., but was plugged back and finally completed as a producer in July, 1937. The 13 3/8 in. casing was set at 1,935 ft. and the 7 5/8 in. long string was set at 10,406 ft.

The deepest well that has been drilled in the Lafitte Field is The Texas Company's State Bayou Norman No. 1, which was drilled to 12,115 ft. during the latter part of the year 1937. This well cored a new oil sand from 12,009 ft. to 12,030 ft. but the well tried to blow out after coring this sand and further drilling was made rather difficult because of the enormous amount of open hole. The 13 3/8 in. surface casing was set at 1,931 ft. which left a total of 10,184 ft. of open hole. The operators feared that further drilling might cause the hole to be junked and decided to plug back and set 7 5/8 in. casing at 9,674 ft. The discovery sand was perforated from 9,530 to 9,630 ft. and the well was completed for 1,736 bbl. daily on a 3/8 in. choke. This particular well is important because it definitely defines another sand below 12,000 ft. and gives reason to ascertain that further deep developments will probably open up new producing horizons in the lower Middle Oligocene and Lower Oligocene formations which to date have not been tested along the Lafitte trend in Southern Louisiana.

Of the 10 wells drilled in the year 1937, nine were drilled to a total depth below 10,000 ft. and eight are producing below this depth. The only well that was not carried to 10,000 ft. was The Texas Company's Rigoletts No. 6 which had a total depth of 9,556 ft. and which is producing out of the 9,400 ft. sand.

TABLE NO. I

Wells Completed in the Lafitte Field

The Texas Company	Total Depth	Numbered in Order of Depth	Completion Depth	Date Completed	Casing Record 13 3/8" O.D. Surface Casing	Casing Record 7 5/8" O.D. Long String	Remarks
Bayou St. Dennis #1	9,572	6	9,572	May, 1935	1,160	9,558	Discovery Well. (9500 ft. Sand)
Bayou St. Dennis #2	9,640	8	9,640	Sept. 1935	1,247	9,575	Producer.
Rigoletts #1	9,568	5	9,568	Sept. 1935	1,193	9,506	Producer.
Rigoletts #2	9,606	7	9,606	Feb. 1936	2,016	9,575	Producer.
Lafitte #3	9,555	4	9,555	Apr. 1936	2,006	9,411	Producer.
Rigoletts #3	9,455	2	9,455	Apr. 1936	1,700	9,396	Producer. (New Sand).
Rigoletts #4	9,406	1	9,406	July 1936	1,887	9,360	Producer.
Rigoletts #5	10,942	20	10,244	Jan. 1937	1,905	10,244	First commercial producer in world below 10,000 ft. Comp. for 1,636 bbls. (New Sand).
R. C. Milling #1[1]	10,040	9	10,040	Jan. 1937	1,937	10,040	Comp. for 1,550 bbls. choked at 9,941-10,040. Second 10,000 ft. commercial well in world and second at Lafitte. (New Sand).
Rigoletts #6	9,556	3	9,476	Apr. 1937	1,902	9,446	Producer.
Lafitte #6	10,368	18	10,018	May 1937	1,988	10,204	Completed for 1,050 bbls. daily.
Rigoletts #7	10,406	19	10,240	July 1937	1,935	10,406	Initially produced 1,382 bbls. daily from 10,210-10,240 ft. (New Sand).
Lafitte #4	10,092	12	10,091	July 1937	1,962	9,363[2]	Oil well at 10,039-10,091 ft.
Lafitte #5	10,057	10	10,020	Sept. 1937	1,913	9,920[3]	Producer.
Madison Realty Co. #2	10,120	13	10,056	Oct. 1937	1,860	10,120	Completed at 10,018-10,056.
Lafitte #7	10,275	16	10,092	Nov. 1937	2,030	10,275	Perforated and completed at 10,-065-10,092 ft.
State Bayou Norman #1	12,115	21	9,630	Nov. 1937	1,931	9,674	Tried to blow out at 12,069 ft. Plugged back; perforated 9,530-9,630 ft. made 1,736 bbls. daily.
Rigoletts #8	10,285	17	10,094	Jan. 1938	1,923	10,285	Perforated at 10,094 flowed 1,575 bbls.
Lafitte #9	10,065	11	10,065	Feb. 1938	1,844	10,065	Producer—1,318 bbls. daily.
Marrero #1	10,260	15	9,606	Feb. 1938	1,937	9,731	Perforated at 9,606 flowed 1,783 bbls.
Lafitte #4 (workover)	10,092	12	8,090	Mar. 1938	1,962	9,363[2]	Plugged back to 8,090. Perforated from 8,035-8,090 flowed 1,495 bbls. (New Sand).
Marrero #2	10,187	14	10,098	Mar. 1938	1,928	10,159	Plugged back and completed at 10,098. Flowed 1,300 bbls.

[1]Name "Milling" was changed to Madison Realty Company.
[2]5 1/2" O.D. Short string in 7" =9,300—10,092.
[3]5 1/2" O.D. Short string in 7" =9,880—10,057.

Drilling barge Rieve on Ile-Lafitte No. 5 well, Lafitte dome.

Production during 1937 totaled 4,105,393 bbl., and since the discovery of the field up to the end of 1937 it had produced 7,474,791 bbl. The total number of wells in the Lafitte Field at the end of 1937 was 17 producing oil wells with no dry holes. During the year 1937 the production shows a rather controlled curve which is somewhat complimentary to proration. This is substantiated with the decline of the per well allowable in 1937 in comparison with the previous two years.

During the year 1938 to the present date, there have been four new completed oil wells that are producing from the regular five established pay sands, and one workover; The Texas Company's Lafitte No. 4, which was first completed as a producer in July, 1937, from a sand at 10,059 ft. to 10,091 ft., the total depth of the well being 10,092 ft. The 13⅜ in. surface casing was set at 1,962 ft., 7⅝ in. casing at 9,363 ft., and 5½ in. casing was set from 9,300 ft. to 10,092 ft. This was the first well in which three strings of casing were used and it is to be noted that the 5½ in. casing was only a short string. In March of this year the operators reworked the well and perforated into a new sand from 8,035 ft. to 8,090 ft. which flowed, 1,495 bbl. on a ⅜ in. choke. This established the sixth producing sand in the Lafitte Field whose producing zones now range from depths of 8,000 ft. to 10,300 ft. with a possible seventh sand producing below 12,000 ft.

Table I lists the wells as they were completed chronologically and the third column of this table numbers the wells by depths (No. 1 the shallowest and No. 21 the deepest). From a study of this table and table No. II, one may grasp immediately the enormous producing possibilities that the Lafitte Field has and from that factor alone, the economic significance of the field becomes of major proportions.

PRODUCING HORIZONS

The Conservation Commission of Louisiana controls the production in the state and it is the Commission's policy to set a per field allowable instead of allowing a restriction on each well. At Lafitte, the Commission last April 1st allowed the field to produce 13,000 bbl. of oil per day from 21 wells. At the present date, the allowable per day is still 13,000 bbl. The spacing rule at Lafitte is set at one well per 20 acres.

Table II shows the number of different sands found in the Lafitte Field. The name of the discovery well for each sand is also given, and the listing is in the chronological order of the sands' discoveries. The accumulative thickness of the producing sand bodies is 370 ft. The seventh sand has been cored from a depth of 12,009 ft. to 12,030 ft., but has not been tested for production. To date there are three proven Miocene sand bodies and three proven Oligocene sand bodies.

From the above, it is evident that the development of the Lafitte Field has progressed very diligently since its discovery, and with a total of 21 producing wells to date and no dry holes, the field has reached even beyond the limits of the original expectations. The wells are producing from 9,400 ft. to 10,500 ft. and over six good sands have been discovered. Exploration has been conducted below 12,000 ft. and evidence of commercial producing sands has been located below this depth. It is highly possible that continuous production could be obtained below 13,000 or 14,000 ft.

Production from the shallower wells (i. e., above 10,000 ft.) is obtained from the

Table 2. Producing Horizons

Company & Well	Sand No.	Depth of Prod. Sand	Age	Status of Sand
The Texas Co. #1 Bayou St. Dennis	1	9,540- 9,572	Lower Miocene	Productive
The Texas Co. #3 Rigoletts	2	9,396- 9,455	Lower Miocene	Productive
The Texas Co. #5 Rigoletts	3	10,030-10,110	Oligocene	Productive
The Texas Co. #1 Milling	4	9,912-10,010	Oligocene	Productive
The Texas Co. #7 Rigoletts	5	10,210-10,240	Oligocene	Productive
The Texas Co. #4 Lafitte (Workover)	6	8,035- 8,090	Miocene	Productive
The Texas Co. #1 State Bayou Norman	7	12,009-12,030	Oligocene	Cored but not tested for production.

Lower Miocene formation and in the deeper wells production is from the Upper Oligocene, which is the extreme upper part of the *Discorbis* zone. It has been discussed by some that it is possible that the deeper sands are still in the basal Miocene zone, however, it is the author's belief that the deeper wells are producing from the Upper Oligocene which is *Discorbis* zone equivalent. No zone below this particular *Discorbis* zone has been tested for production in the field, however, one of the wells, The Texas Company's State Bayou Norman No. 1 was drilled to a total depth of 12,115 ft., and a good sand was cored from 12,009 to 12,030 ft. It is highly probable that this well penetrated into the Lower Middle Oligocene section, which is probably Lower *Heterostegina* or *Marginulina* equivalent. It would be interesting for a test to be projected and drilled to what is known in Texas as the *Frio* level and which is one of the most important producing horizons in the Texas Gulf Coast. Opinion is divided among geologists and paleontologists whether or not the *Frio* sand section in the Louisiana Lafitte trend is present. One group maintains that the section "shales-out" considerably and that no *Frio* sand would be present, and others claim that even though the section might "shale-out" to some extent, the *Frio* equivalent would be present even though paleontologists might name it by some different terminology. Nevertheless, it is highly possible that production will be obtained below the levels from which the field is now producing whether they be the lower part of the Middle Oligocene or into the Lower Oligocene.

PRODUCTION METHODS

The Lafitte Field is located in the marshy section of Jefferson Parish and the entire field is a continuous marsh with very little vegetation apparent. Two aerial photographs show the condition that exists in the field. The area is so marshy that The Texas Company is obligated to dredge out canals in order to drain the area, as well as use the canals for location sites in the drilling and completion of the wells. Operations of this kind are extremely costly as well as difficult and The Texas Company's Production and Engineering Departments are to be complimented for the efficient manner in which they have developed this field to date. The facilities and equipment on the ground are extremely neat and well constructed for a marshy area of this type and all operations have been conducted on a small but consistent scale. Three rigs are used to develop the area. All of these rigs are rigged up on The Texas Company's special submergible barges. These barges are unique in that they are floated out to the location site and thence sunk to the bottom of the canal, which, in turn, serves as a foundation. There is a separate barge for boilers.

Boiler barge De Soto in foreground and drilling barge Rieve in the rear—these are sunk to the bottom and can be floated from location to location.

Production methods at Lafitte are so devised as to take care of the surface handicap and topographical features in which the field is situated. Due to the marshy and swampy areas it was necessary for The Texas Company to dredge out canals to the individual locations. The main canal that runs through the field is known as the Dupree Cut which was dredged by the United States Government in their attempt to open up the inland area in that vicinity. All lateral canals that lead out from this particular cut were dredged by The Texas Company. In the initial operations of the field when the first well was drilled as a wildcat the facilities were so limited as to take care of only immediate needs. The rig was moved in by water on the so-called "floating barges" that are a particular feature of The Texas Company's water operations. It is a customary practice by The Texas Company in drilling tidewater leases and canal locations to use submergible drilling barges wherever possible. Under ordinary drilling operations, according to Mr. L. G. McBride (pp. 246-248, May 1936, WORLD PETROLEUM), a saving of $15,000.00 per well can be effected by the use of barges instead of rigging up on a foundation of creosoted timbers. Drilling from submerged barges, however, is only practical on locations where the water ranges in depth from five to twelve feet. These drilling barges are usually of the twin-hull type, so designed that they are capable of floating an entire steam rig, with exception of the boilers, including racks for drill pipe and casting, engine house, mud pits, mud pumps and 136 ft. derrick. The most recent twin-hull barges are 56 ft. by 126 ft. overall with hull 10 ft. deep and super-structure 11 ft. high.

The boilers, feed pumps and a 1,000 bbl. water supply tank are mounted as a separate unit on a barge of similar design. In preparing to drill a canal location at Lafitte, the complete rig including 1,000 ft. of 4½ in. drill pipe and 9,500 ft. of 7⅝ in. casing is mounted on the barge and towed to the location. By filling the hull with water the barge is submerged until it rests securely on the bottom of the canal. To prevent movement after drilling operations have begun approximately 14 piles are required to anchor firmly both the rig barge and the boiler barge. A remarkable feature in the use of these barges is that they are moved from location to location without the dismantling of any of the equipment. The entire machinery, including pumps and draw works, are left entirely intact and the derrick, which is 136 ft. high, is also left standing. The plans of the barges are so constructed that they will not turn over even though the derrick should become top heavy when the transportation from location to location is made. At the present time, there are three rigs in operation in the field. Immediately after the discovery well was completed, The Texas Company moved in a second rig and the two rigs developed the field until the latter part of 1936. A third rig was moved in and the three rigs have been developing the field for the past year and a half. All of these rigs are mounted on barges. There are six barges in all, three for the rig proper and three for the boiler set-ups. After a well is completed and a new location is made, it requires only a few hours for the water to be pumped out of the hulls of both barges and for the transfer of the complete unit to the new location. Operations can commence the same day. Drilling conditions are almost ideal as far as the nature of the sediments are concerned and it requires approximately 45 days to attain

Aerial view of Lafitte field showing the marsh which surrounds the entire area—all canals are dredged.

a depth of 9,500 ft. and approximately 60 days to attain a depth of 10,000 ft. Drilling for the first 7,500 or 8,000 ft. is very rapid but when coring levels are reached, the drilling is slowed up considerably.

When the new well is commenced, approximately 100 ft. of 18-in. conductor pipe is set in order to protect the hole from the sloughing-in of the surface swampy muck and mire. This conductor pipe is pulled out of the hole after the surface casing has been set and is used over again in other wells. It is the common practice to pull this conductor pipe, but, in one or two instances the pipe was stuck so fast that it was left in the hole. The 13⅜ in. surface casing is set from depths of 1,100 to 2,000 ft. and is cemented with 200 sacks of cement. Forty-eight hours are allowed for the cement to harden around the surface string. A 9⅞ in. hole is then drilled below the surface string. The mud used for the first 7,000 ft. ranges in weight from 9¾ lbs. to 10 lbs. and after that depth to the completion of the hole, the mud weight is increased from 10½ lbs. to 11 lbs. No excess mud material is needed for the Lafitte operations. The viscosity of the mud ranges from 23 to 26 second, conducted on A. P. I. funnel measurements. Blow-out drills are conducted on every crew and every precaution is maintained to prevent blow-outs during drilling of the wells. The cuttings of the drilled hole are obtained at intervals and paleontological determinations are made on them by the field paleontologist who, by the knowledge of other wells already completed, gives the coring depth. The wells are cored by the wire line method and also by the conventional method. In the wire line method, a core barrel assembly with a catching latch on top of the core barrel is dropped into the drill pipe while the pipe is in the hole and this barrel is pumped down the pipe until it becomes snugly inserted into a hole in the corehead-bit. After it is in place the core is cut and the barrel is ready to be pulled. An overshot fishing tool, especially made for catching the latch on the core barrel, and which is attached to a ⅝ in. wire line is dropped into the drill pipe and this overshot falls over the latch on the core barrel and catches it and is pulled out by small engines attached to the wire line reel. The barrel is dropped into the hole, core is cut, pulled out and looked at in about an hour and a half's time in the deep holes.

The Texas Company has also used the conventional barrel for coring purposes. In the conventional method, the barrel is inserted in the drill pipe while the pipe is out of the hole and thence lowered into the hole to cut the core. The pipe then has to be pulled out again in order to retrieve the core. In other words, a round trip, which takes approximately 10 hours on the deep holes, is necessary in order to obtain a conventional core, whereas by the wire line coring, between five and seven cores can be obtained in that length of time. There is no set rule for the coring at Lafitte as far as these methods are concerned. Whenever a larger core is demanded by the operators, then it is best to use the conventional core barrel because it cuts a much larger core than the wire line.

After completion of the hole an electric log survey is made on each well before the casing is set. From these electric logs the exact sand thicknesses and all correlation points are obtained.

After the sand has been determined and a production test is arranged, 7⅝ in. O.D. casing is set to the bottom of the hole and perforations are made through the casing into the sand. From 1,200 to 2,000 sacks of cement are used in the cementing of the long string. The usual 72-hour waiting on cement time is the limit required before preparations are made to complete the well. Screen and tubing are then set for the final production test. It is customary for The Texas Company to seal the tubing in the liner above the screen, which eliminates any pressure in the casing. All of the flowing pressure is in the tubing. This is done for a safety factor in that if anything should happen to the well after completion, in the form of a blowout, there would be only one string of casing that would have to be dealt with, which in this case would be the tubing.

The water for drilling purposes is generally used from the canal, but, at times it becomes highly brackish and in such cases fresh water, which is barged in, is used. Gas is furnished to the boilers from other wells already completed in the field. A central distributing system is maintained on each well which furnishes the gas for the drilling of the wells on the lease. The wells are washed in with clear water and brought in on small chokes and the pressure on the tubing ranges from 1,000 lbs. to 3,300 lbs. per square inch. A convenient gathering system is constructed in the field where the oil flows to tanks near the outlet terminal.

In several instances, the 7⅝ in. casing has been set after several sands have been cored and the operators decided to continue drilling into the 10,000 ft. sands. In such a case, a 6⅛ in. hole is used below the seven inch casing and after the hole has been completed, 5½ in. O.D. casing is then set from the bottom of the hole to just a few hundred feet inside the seven inch casing. In other words, a short string of five inch casing is used which is packed off inside the seven inch. This type of drilling affords protection to the upper sands and yet permits the operators to test the lower sand if necessary.

One of the most unusual features in the entire development of Lafitte production is that, in the majority of cases, only two strings of casing are set in the final completion of the wells. The formations stand up so perfectly under the influence of ordinary drilling, with just normal care given to the mud, that a string of 13⅜ in. surface casing and a string of 7⅝ in. casing is used for the completion, or oil string. This feature is not only remarkable because of the extent of the 9,000 to 10,000 ft. of open hole, but that it is a tremendous saving factor for the operating company in that the cost of the wells is reduced considerably.

Table No. I shows the casing record for each well in the field. It must be remembered that in each case, conductor pipe is set to 100 ft. but is pulled out. This conductor pipe is not shown in this table. In a total of 21 present producing wells 38,204 ft. of 13⅜ in. casing has been set, 206,313 ft. of 7⅝ in. casing, and 969 ft. of 5½ in. casing. A total amount of 211,470 ft. of hole has been drilled. In other words, out of 211,470 ft. of hole drilled, 98 percent has been cased with pipe.

SEA-GOING OIL FIELD

MANY wells have been drilled in the tidal waters, inlets, and bayous along the Louisiana and Texas shores, but the first essentially marine field was opened in March, 1938, with completion of the discovery well of the Creole field known as Superior-Pure Gulf of Mexico State No. 1. This well, operating in a water depth of 14 ft. and located a trifle over a mile from the shore line of Cameron Parish, Louisiana, may be the forerunner of many others to be put down in this part of the Gulf of Mexico, some of them possibly even more distant from the shore.

Superior Oil Company of California and The Pure Oil Company are joint holders of 40,000 acres of leases in Creole, part of which is state land, and part individually owned.

The history of the discovery goes back for almost a decade, for geological and geophysical work had been carried on by The Pure Oil Company on the Gulf Coast of Louisiana for many years. The marshes and bayous of the coast have required special methods of survey and transportation, for with the development of the seismograph method of exploration, it became necessary to transport men, instruments and dynamite across extensive marsh areas. Geologists traveled across the marshy sections in specially designed marsh buggies, paddle-wheeled motored conveyances which would not bog down in spongy, wet areas. Much the same methods were used, it has been said, in discovering such domed fields as Gueydan, Bosco, and Sweet Lake which are also in the Gulf Coast region.

In working southwest from Sweet Lake with the seismograph, evidence of doming was discovered west of the town of Creole and work done along the shore indicated that the prospect projected out into the Gulf. As a result of such geophysical work, 7,000 acres of leases were taken on the shore. Later, 33,000 acres of Louisiana state land extending out into the Gulf were acquired adjacent to the block held on land.

The new location is about half way between Cameron, Louisiana, and the mouth of the Mermentau River. It is seventy miles by water route to Pure Oil's refinery at Smiths Bluff, Texas, and about thirty miles due south of the city of Lake Charles, Louisiana; it is about 180 miles west of New Orleans.

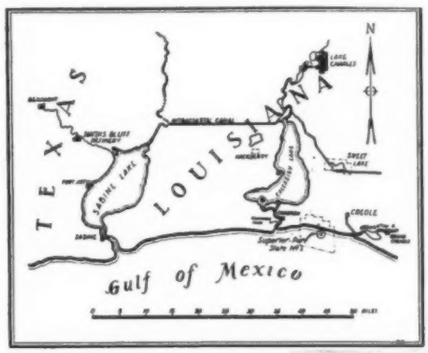
Up until a few years ago the shrimping port of Cameron was reached by steamboat from Lake Charles. Recently a highway has been completed which makes it possible to drive to Cameron and then along the sandy ridges, or cheniers, east to Creole and Grand Chenier. These small towns which are inhabited mostly by people of French descent, are located on high ground near the Gulf, and between them and the main land are long stretches of almost inaccessible marsh land. These marshes, which appear desolate and uninviting, are the winter feeding grounds of millions of ducks and geese.

Development followed seismograph surveys and the first well was spudded in October 6, 1937. Prior to drilling, however, a considerable amount of preliminary work had to be done under sometimes difficult conditions. Piling had to be driven and a timber platform built on top to serve as foundation for the 136 ft. steel derrick. Mud storage tanks, water and fuel tanks had to be provided. The driving of several hundred 70-ft. piles and building of the superstructure consumed approximately six months time. All materials had to be conveyed from Cameron, 10 miles distant, and the workmen had to be transferred from and to that point daily. In the open waters of the Gulf the trip in small boats, while not dangerous, was frequently unpleasant, and it sometimes happened that the crew could not be landed on the derrick platform. In a few instances they were marooned at the well site for a couple of days at a time.

Diesel-electric power was used in drilling the well. Two Diesel engines of 350 h.p. drove two electric generators, one of which supplied power for the draw works and the other for the mud pumps. Drilling encountered only the obstacles frequently met in land operations. The first string of casing, 10¾ in., was set at 1,157 ft. A second string of 7⅝ in. was set at 7,166 ft. The lowest depth reached was 9,394 ft. where a stuck drill stopped progress. The well was plugged back to 5,610 ft. Casing was gun-perforated between 5,110 and 5,130 ft. where a saturated sand had been logged on the way down. The well came in March 14 with an estimated production of 10 bbl. per hour from the Miocene through a 7/64 in. choke with a tubing pressure of 550 lbs.

Further drilling will be necessary to answer the question about the size of the field which may be expected. However, geologists have pointed out that considering the type of dome which has been outlined, together with the records of the first test drilled, that an area of some magnitude may be developed. A second location has been made on the shore about a mile and a half northwest of the discovery.

With the opening of the Creole field, the oil industry, which already has penetrated three miles below the earth's surface and has extended its activities to hitherto unexplored jungles and desert wastes, annexes a new domain by going to sea. Within another decade it is probable that derricks may dot the Gulf of Mexico at points entirely out of sight of land. There are many places where the water for distances of 25 to 30 miles out is sufficiently shallow so that no serious mechanical obstacles to drilling exist. Meanwhile, with some 4,000,000 to 5,000,000 acres of land-locked and shallow coastal waters between the mouths of the Mississippi and the Rio Grande, there is ample room for the driller to exercise his skill. Undoubtedly many marine fields will be added to the known resources of the rich Gulf Coast.



Map showing location of the Creole field. Right—Superior Pure State No. 1 in the Gulf of Mexico.

JUNGLE DRILLING May Open Area in Eastern Peru

Looking toward the camp at Agua Caliente, Peru, from the landing.

American Capital and Technical Experience Combine With Progressive Peruvian Government in Developing Ganso Azul Concession in Remote Region of Eastern Peru Near Headwaters of Amazon System.

FROM a land plane over the jungles of Eastern Peru, a California geologist on a scouting expedition observed a structure favorable for the accumulation of petroleum.

From this chance observation between San Ramon and Masisea in the 1920s resulted a series of circumstances that may well prove of inestimable importance to the future of Peru. This country is divided by mountain ranges into three sections: the coastal area, for centuries the most important. It is here that the Inca Empire was built on the rivers of a far older culture in the highlands and gradually extended its domination over primitive groups living on the coastal plane. Inca civilization was based on well built towns drawing their sustenance from the neighboring valleys on the west slope of the Andes. Before Pizarro and the Conquistadores arrived, a well developed system of irrigation bordered the rivers that tumbled into the valleys from the Andes.

Between the Andes and the Eastern Cordillera lies the high plateau, sparsely inhabited by Indians, practically undeveloped but now attracting the attention of the Peruvian government because of its agricultural, mining and grazing possibilities.

The third section of Peru, almost inaccessible by direct travel from the west coast is the tropical region. Here Iquitos flourished as a great rubber shipping port on the Amazon in the steaming tropical jungle. Iquitos, a shadow of its former grandeur, is reached by steamer 2,000 miles up the Amazon and even at that distance from the mouth of the river, provides docking facilities for ocean going steamers. Alternatively it may be reached from Lima by the Central Railroad to the plateau, crossing the western range of the mountains at 15,000 ft., across the plateau by auto to San Ramon and down mule trails to Masisea on the River Ucayali flowing ultimately into the Amazon. Today, of course, there is the inevitable South American mail plane.

In order to survey the possibility of a railroad to Iquitos the party containing the California geologist elected to fly from San Ramon to the intermediate point representing their immediate destination. While on this flight the keen observation of the geologist led to application to the Peruvian government for an oil concession in the Pachitea region on the River Ucayali. Through the enlightened cooperation of the government the concession was granted with the right to make denouncements of selected areas under the regular petroleum laws.

With the concession in order a party of three southern California geologists again penetrated this region from the west by rail, auto and plane to Masisea. Here the party embarked in dugout canoes powered by American outboard motors. This means of transportation proved very satisfactory although gasoline must come from Iquitos 600 miles up the Ucayali bearing the Texaco and Standard of Brazil labels and costing 93 cents a gallon.

In this area the temperature hovers around 85 deg. F. in the daytime, dropping to 70 deg. F. at night. There is a very high degree of humidity which adds to the discomfort. No malaria or amoebic dysentery, curse of the tropics, exist in the district. Wild turkeys and wild pigs are available and the rivers are abundantly furnished with fish. Fruit, surprisingly, is rare.

While geological methods are essentially the same as elsewhere it is necessary to do much fundamental work that is obviated in better mapped areas. Base maps, of course, are not available. In making base maps, the party used stadia traverses along the main rivers to tie secondary traverses into the jungle. Geographical locations by astronomical observations, necessary to fix the concession boundaries, was obtained by a Wild Theodolite and time signals from Arlington, D. C., by short wave.

Finally, in 1931 a denouncement of 5,000 pertenencias was made. A Peruvian company known as Compania de Petrolio Ganzo Azul had been formed to exploit the concession. This company is backed by

American capital, has headquarters in Lima, Peru, and is officered by experienced southern California oil men. A camp known as Agua Caliente was established on the concession and arrangements were made with J. E. Brantly, California oil producer and drilling contractor, to sink several test wells. Mr. Brantly had had wide experience in drilling in South America as well as in Texas and California. Mr. Brantly therefore made plans for, and through the facilities of his Drilling and Exploration Company acquired, an outfit comprising a medium weight steam rig capable of handling some 8,000 feet or more of four inch drill pipe and 100 tons or somewhat more of casing. After a serious study of the conditions under which the well is to be drilled, the nature of the local climate and the transportation difficulties, the conclusion was reached that steam, even though the burning of wood for fuel will be necessary, would be the most satisfactory and the least

A rear view of the staff house at the Peruvian encampment which may vastly increase the usable area of Peru if plans matured here prove successful.

Site of the landing where four months were spent in constructing facilities for landing hundreds of tons of drilling equipment from a river that may vary 20 ft. in level within a few days.

likely to give trouble that might require the shut down of the rig and consequent loss of time. Direct mechanical drives were considered, but for the reason suggested above they were not selected. Diesel electric power and drives, though highly satisfactory, under ordinary circumstances, are not considered sufficiently free of trouble that can be readily corrected in the field to permit their use on such an isolated location. Therefore, in view of the apparent wisdom of shipping equipment thoroughly understood by all members of the crew and

Native transportation along jungle rivers in Peru; later vastly improved by installation of outboard motors.

Constructing bridges in the jungles near Ganso Azul, an important step in the development of the oil camp.

of placing on the ground machinery of a type least likely to give trouble, steam was selected.

The power plant and machinery consist of four 125 h.p. 250 lbs. working pressure boilers with feed water heaters utilizing the exhaust steam from the mud circulating pump, two direct acting steam pumps, one having a capacity of approximately 200 hydraulic horse power and the other 150 hydraulic horse power. Two eleven by eleven Babbitt bearing engines were included in the inventory, one to drive the hoist and the other the sandreel. These two engines are identical and interchangeable in all of their parts. The hoist is of the four-speed type with a seven inch drum shaft, the table is of 18 in. size, and the hook, traveling block and crown block of 150 tons rated working loads. A one inch wire line will be used in a 122 ft. steel derrick. The drill pipe included in the shipment was 6,000 ft. of 5 9/16 in. 2,000 ft. of 4½ in. and 6,000 ft. of 3½ in. internal flush.

It is contemplated that the productive possibilities will be within 6,000 ft. of the surface. The program provides for the setting of approximately 600 ft. of heavy 11¾ in. casing to be cemented solidly from top to bottom through which a 10⅝ in. hole will be drilled. Upon encountering zones in which production may be expected hole size will be reduced to 8½ in. and drilling continued with wire line core barrel equipment. When the nature of the formation warrants, drill stem tools will be employed to test the formation. In the event of a test warranting the running of casing, 7⅝ in. pipe will be used. The 3½ in. internal flush drill pipe will be used for drilling out and also as tubing if necessary. A drilling gate valve together with blowout equipment capable of packing around both the drill pipe and the kelley will be used.

The crews organized by Mr. Brantly consisted of one tool pusher, three drillers, a transportation man and a welder both of whom are likewise drillers. The crews other than these Americans are made up of native Peruvians obtained from the Amazon Basin Country of Eastern Peru. Though these men are entirely inexperienced in such work, no considerable difficulties have been met in training them for rig helpers.

The camp has a superintendent, a geologist, a doctor and a radio operator.

The inventory shipped to the mouth of the Amazon and then 2,600 miles up this river and the Ucayali contained a strange assortment of goods: garden seed, fire-brick, library, playing cards, victrola, short wave sending and receiving sets, fishing tackle, and small rifles for game. Welding equipment, a blacksmith shop, trucks and tractors, winches all went into the hold of the ship bound for remote Agua Caliente in the Peruvian jungles.

Meanwhile, in the jungle a small but efficient force worked long hours to have the landing, camp and roads to well site completed before the equipment arrived. Bridges had to be constructed, an eight mile road completed, sheds and living

Outline map showing distance from the Amazon mouth to Agua Caliente.

quarters erected, 1,200 cords of firewood cut ready for the rig boilers. A reservoir with a capacity of 70,000 gallons of water had to be built. It was necessary to protect the landing from river floods that rose 20 ft. above the normal water level. The road from landing to camp traversed swamps and gullies.

It had been planned originally to do this work in the summer of 1936, but difficulties developed in Lima when only preliminary surveys had been carried out. It was not until July of 1937 that work was resumed. And, even before actual work could be started, native labor had to be trained to operate trucks and tractors, construct roads by pick and shovel only. Food had to be gathered from the surrounding country which, while fertile, abounded in insect and other pests that made it difficult to retrieve such food as did grow. Labor turnover, always high in this area, was greatly accelerated when the quality of the food showed any falling off. Peak employment of native labor amounted at times to 185 men but the personnel was constantly changing as each contingent earned what they considered sufficient funds. On the bright side of the ledger it was found that the workmen, when they did work, were excellent. Only natives, accustomed to the damp hot climate of this tropical region, could have moved hundreds of tons of material over the thick gumbo road in the occasional downpour and maintained a cheerful and willing attitude. Like the geological party which traversed this area six years earlier, the diet of fish, plantains and rice was occasionally varied by wild turkey and wild pig.

The work had to be finished in four months.

With the tiny camp, like a speck in the huge jungle, completed news of disaster reached the landing. The ship carrying an important part of the drilling equipment sank half way up the Amazon, near Manaos, Brazil. More heart-breaking delays loomed but later word from down river was more cheering. Much of the cargo was being salvaged. In the north another ship was being loaded to replace equipment that might be irretrievably lost or damaged in the river.

The cargo was lost during the first months of 1938 but already much of it has been recovered while supplementary cargoes are en route. The underwriters have completed a survey of the loss. Finishing touches have been put on the landing, camp and connecting roads.

Before autumn the first test well should be completed.

The progressive intention of the Peruvian government may soon be realized. The discovery of commercial quantities of petroleum near Masisea would certainly result in opening up this tropical area. Highways, towns, exploitation of mineral wealth and the taming of the jungle may reward the foresighted government, should the test, soon to be drilled, prove successful.

An oilfield in Eastern Peru would be of incalculable importance to the Republic. Not only would it add to the usable area of Peru by uniting the east with the western coast area, but it would furnish the fuel and incentive for more permanent transportation facilities to the Colombian and Brazilian borders, assuring Peruvian territorial integrity. It would give Peru an eastern seaport in fact as well as in theory.

Early in the development of the camp the dispensary (above) was established. The thatched-roof warehouse is shown

Peruvian rat (!) A Ronsoco shot on the Ganso Azul concession in the interior jungles of eastern Peru.

KUWAIT OIL STRIKE

KUWAIT Oil Company Ltd. has announced that oil was struck in its Burgan No. 1 well between 3,674 ft. and 3,692 ft. on April 22nd. A considerable part of the lower portion of the hole is uncased and the well cannot be thoroughly tested until further casing has been run. This is the second test sunk by the joint subsidiary of Anglo-Iranian and Gulf Oil.

PRACTICAL Features of Diesel Electric Rig in Service

By J. E. Brantly

In regions in which fuel costs are high and water inadequate in quantity, costly or of a character detrimental to steam power plants, it becomes necessary, in practicing proper economy, to resort to the use of power driven drilling rigs. The operator has a choice of several types; for example, internal combustion engines driving directly to the hoisting equipment and mud circulating pump, and internal combustion engine-electric generating sets driving the hoisting equipment and pump through individual motors. These internal combustion engines may be fueled with Diesel oil, butane, natural gas or gasoline and the electric generators designed to produce either direct or alternating curtent. The equipment to be discussed here is a Diesel-electric power plant generating direct current to be supplied to individual motors which drive the various machines of the drilling rig.

In selecting a Diesel-electric power plant there are several choices which may be made; namely, a relatively slow speed engine connected by a belt drive to a higher speed generator, a high speed engine so connected to a high speed generator, a slow speed engine connected directly to a slow speed generator and a high speed engine directly connected to a high speed generator. The lower the speed of both the Diesel engine and the generator, the greater its weight, and conversely, the higher the speed of these two machines the lighter the weight and also the lower the cost. Each of these types of generating sets has its particular field of usefulness. Obviously the heavier equipment is less portable and the high speed lighter equipment, particularly in small units, may be transported much more readily. The character of the work to be done and the conditions under which it is to be done must therefore determine the size and type of the equipment to be selected. The work to be done by the equipment herein discussed involves the drilling of 5,000 or 6,000 ft. holes with 4½ in. drill pipe and as deep as 8,000 ft. holes with 3½ in. drill pipe. Owing to the small sizes of the bores and the nature of the formations being drilled approximately 150 hydraulic horsepower, or the use of a 7¼ in. by 14 in. mud circulating pump was considered satisfactory. Portability was a prime requisite and maximum hoisting speeds of minor importance.

An analysis of the work to which the rig was to be assigned led to the selection of four high-speed direct connected units developing 60 kw. at normal rating.

These Diesel engines have eight cylinders each of 4½ in. bore and 5¾ in. stroke with a total piston displacement of 732 cu. in. At normal operating speed of 1,200 r.p.m. they develop approximately 100 h.p. which may be increased to 120 h.p. by speeding up to 1,400 r.p.m. for intermittent hoisting service. These speeds will deliver respectively approximately 90 and 108 h.p. on the output side of the generator.

Each of these four Diesel engines operates a 60 k.w., 1,200 r.p.m., 250 volt differential generator having a five kilowatt 125 volt quill type exciter. With the variable voltage control the engine speed is maintained approximately constant and the voltage of the generator is controlled by varying the field of the generator. This variation is accomplished by inserting or removing resistance in the field circuit. The variation and voltage on the generator varies the speed on the motor to which the generator is connected.

These generating units weigh approximately 8,000 lbs. each complete, giving a total of 32,000 lbs. for the four units. They are mounted on a 20 ton capacity three-axle trailer having six dual wheels, or 12 tires on the ground. The trailer is floored with two inch boards covered with steel and has a roof and ends of galvanized iron over-steel angles. The sides are so constructed that the lower half folds down as an extension of the engine room and the upper half folds upward as a continuation of the roof. In addition to the power units and the housing, other equipment such as starting batteries and wiring give a total over-all weight of approximately 40,000 lbs. on the trailer chassis. As indicated in the photographs all wires lead beneath the floor of the engine house where they are permanently fixed in conduit and flexible tubing. As a means of holding the weight off the springs and the rubber of the trailer, during periods of operation or standing idle, there are six screw jacks attached by welded plates to the frame of the chassis. When the trailer is rolled into position the jacks are lowered, placed on six inch by eight inch timbers and screwed out until the trailer floor is level and the weight has been practically entirely removed from the axles. When not in service these jacks are folded upward and swung on chains from the frame. As a further precaution against vibration and shaking, the timbers on which the jacks rest are chained to the frame and load finders used to hold tension between

FIGURE 1.

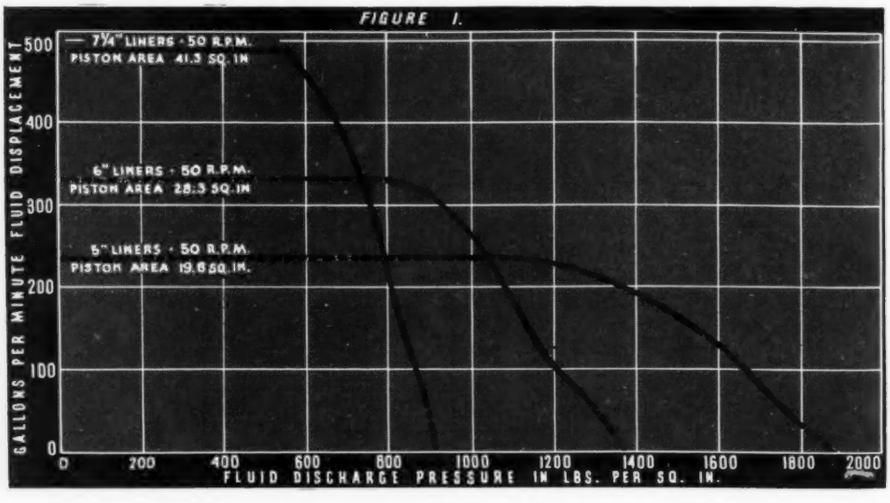
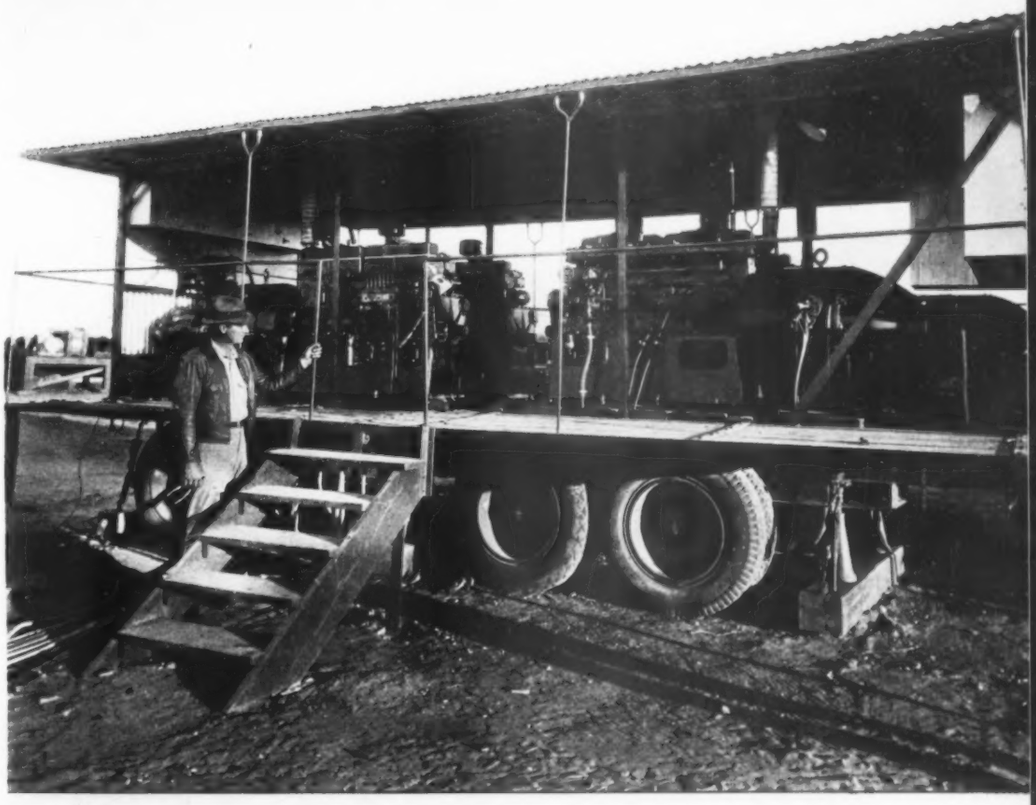


Figure 1—Pressure-volume characteristics: 7¼ in. by 14 in. power pump; normal speed, 50 r.p.m.; mechanical efficiency, 75 percent; volumetric efficiency, 95 percent; normal mud laden fluid; driven by 200 h.p. D.C. motor; maximum piston load 22,000; three liner sizes adequate.

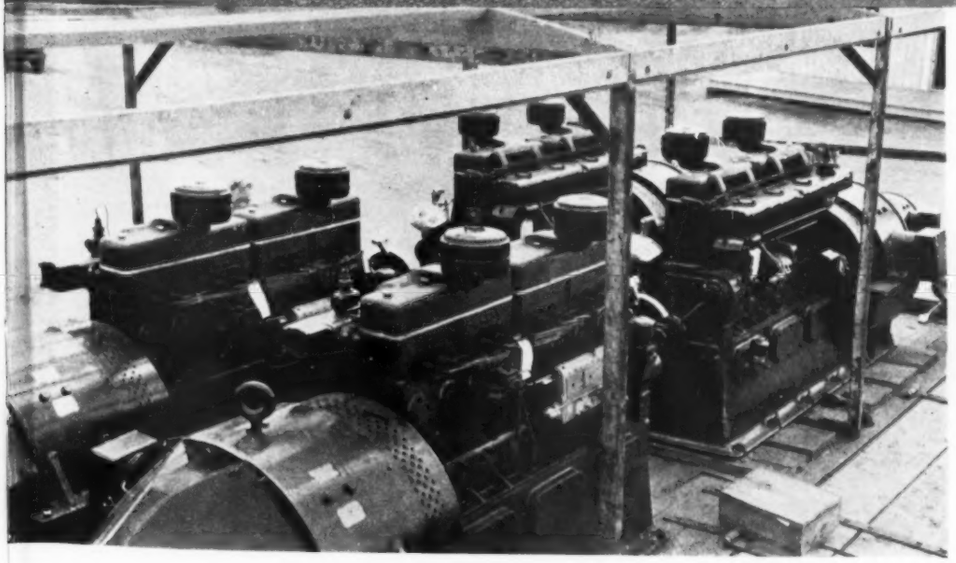
the ends of the timber and the trailer frame, as shown in one of the photographs.

The control panels are mounted on a specially designed underslung trailer with conductor cable boxes at either end. The fuel tank of 600 gallons capacity is likewise mounted on a trailer.

The cooling system is composed of a heat exchanger built up of copper tubes between cast iron ends and mounted over a steel tank twelve feet long, six feet wide and four feet deep. Water from this tank is circulated over the copper tubes of the heat exchanger by means of a centrifugal pump driven by a three horsepower motor. A circulating water temperature of 160 deg. is maintained. This cooling system is likewise mounted on a trailer, though it is not so shown in the accompanying photograph. When set in position at the rig the power plant is placed 150 ft. from the derrick floor on the windward side with the control



Four unit Diesel electric power plant, mounted on 20 ton trailer, with control panel, fuel tank and cooling tower on location.



panel trailer about 15 ft. from the power plant and between it and the rig. The electric power lines pass from beneath the floor of the trailer to the control panels, thence to the control boxes and switches at the driller's position on the rig. From this point leads are run to the drawworks motor, the rotary table motor, the main pump motor, the auxiliary pump motor, the shaker screen motor and the blower motor. These controls at the driller's position are so arranged that he may start or stop each generating unit and each motor all from his floor position; also, the controls are such that he may apply the power from all four generators to the drawworks prime mover, any two generators to the working pump motor and any one to the rotary table motor or to the auxiliary pump motor.

The drawworks motor is of 225 rated

capacity capable of running 100 percent overload for intermittent service, which permits the use of all four generating units delivering approximately 400 h.p. to the drawworks motor. This motor is so controlled and wound that it has 20 speed changes in each direction varying from almost imperceptible motion to its top speed of 900 r.p.m. With four speeds on the drawworks this gives maximum required flexibility.

The working pump motor is of 150 h.p. capacity and operates normally at 800 r.p.m. This motor will likewise operate intermittently at considerable overload. The pump manufacturer claims that the power end of the pump is capable of delivering 150 hydraulic horsepower at a maximum piston load of 22,000 lbs. Two of the generating units operating at 1,200 r.p.m. are capable of delivering 180 h.p. to the prime mover of the pump and about 135 hydraulic horsepower. In order to obtain maximum fluid delivery it is necessary to increase the operating speed of the two generators driving the pump to approximately 1,300 r.p.m. It is essential that the operating crews realize that a power pump can deliver safely only so much fluid at a certain maximum pressure or a definite amount of hydraulic horsepower. If too much power is delivered to the power end of the pump it is likely to be destroyed. The prime mover is connected to the pump by 10 V-belts of 15 h.p. each. The rotary table is driven by a 75 h.p. motor operating normally at 800 r.p.m. and is connected to the table through gears, giving a ratio of 200 r.p.m. on the table at normal motor speeds. This motor should be slightly larger. The table may also be driven from the hoisting motor as usual and the table motor may drive the hoist.

The auxiliary or service pump is operated by a 25 h.p. 800 r.p.m. motor. This pump is 4½ in. by 10 in. in size and is used for mixing and shifting mud, cleaning pits and general service around the rig. The shaker screen is driven by a three horsepower 1,800 r.p.m. motor.

Each of the motors on the rig is built with a separate blower mounted on top of the motor. These were removed and a single blower placed in a steel blower house placed 100 ft. from the rig on the windward side. From this point eight inch, 22 gauge galvanized iron piping is run to the rig from which five inch leads are carried to the pump drawworks and rotary table motors. This assures that the cooling air going through the motors will not be gas laden in the event the well should make gas or oil, and permits operation of the electric motors on the floor while the well is being brought in.

The acompanying Figure 1 shows the pressure volume characteristics of a 7½ in. by 14 in. power pump operated by a 150 h.p. motor, into which is delivered the output of two generating units delivering approximately 100 h.p. each. Figure 2 shows the hoisting curve using four generating units delivering 360 h.p. into the hoisting motor. By increasing the speed of the Diesel engines, somewhat better characteristics may be had, though it may be observed that comparing Figure 2 and Figure 3 the latter of which is operated by a steam engine delivering 560 b.h.p., that the steam rig saves five minutes on a round trip in a 4,000 ft. hole, 12 minutes on a round trip in a 6,000 ft. hole and 19 minutes on a round trip in an 8,000 ft. hole. The saving of time is of little consequence.

In moving the rig a heavy duty truck hauls the drawworks and tows the power house trailer. Light trucks tow the other three trailers. Moving and rigging up can be done in 12 to 18 hours on a short move. The rig has drilled two wells in time equal to a steam rig powered by three 125 h.p. 250 lbs. working pressure boilers.

Figure 2—Hoisting curve idealized.

Prime mover 360 b.h.p.; drawworks, blocks and line taken at 75 percent efficiency; 4½ in. drill pipe at 20 lb. per ft.; buoyancy of drilling fluid considered to offset friction between pipe and fluid.

Depth of Hole	Total Actual Hoisting Time		Total Time Pulling Out
4,000 ft.	25 min.	+ 45.00 x 35 =	0 hr. 56 min.
5,000 ft.	37 min.	+ 56.25 x 35 =	1 hr. 15 min.
6,000 ft.	52 min.	+ 67.75 x 35 =	1 hr. 35 min.
7,000 ft.	66 min.	+ 79.00 x 35 =	1 hr. 57 min.
8,000 ft.	82 min.	+ 90.00 x 35 =	2 hr. 20 min.

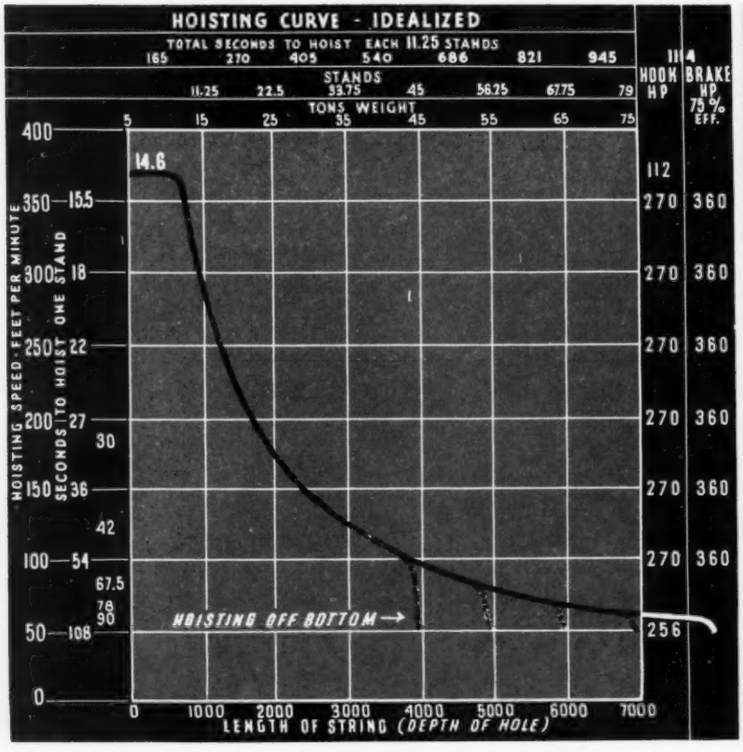
Add 35 sec. for each stand setback.
Add 5 min. for each kelly setback.

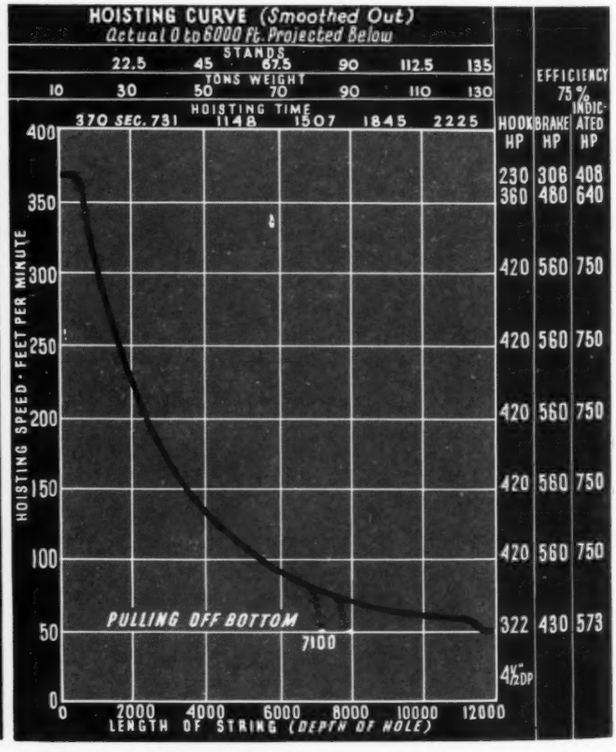
Figure 3—Hoisting curve (smoothed out).

11 in. by 11 in. twin cylinder, slide valve, babbitt bearing engine on 250 lb. dry saturated steam; drawworks blocks and line taken at 75 percent mechanical efficiency; 4½ in. D P weight 20 lb. per ft.; buoyancy of drilling fluid considered to offset fluid friction.

Depth of Hole	Total Actual Hoisting Time		Total Time Pulling Out
4,000 ft.	18 min.	+ 45.0 x 35 =	0 hr. 51 min.
6,000 ft.	38 min.	+ 67.5 x 35 =	1 hr. 23 min.
8,000 ft.	63 min.	+ 90.0 x 35 =	2 hr. 1 min
10,000 ft.	93 min.	+ 112.5 x 35 =	2 hr. 39 min
12,000 ft.	130 min.	+ 135.0 x 35 =	3 hr. 31 min.

Add 35 sec. for each stand setback.
Add 5 min. for each kelly setback.





DEEP WELLS Multiply Pressure Control Problems

By H. C. Otis

President, Otis Pressure Control, Inc.

SINCE the minimum potential bottom hole pressure for which fast, positive and dependable control should be provided in a drilling well passes the 3,000 lbs. per sq. in. mark below 7,000 ft. it is readily apparent why considerable study and attention is being given to surface control equipment by operators drilling for deep production. Experience has indicated that the minimum potential bottom hole pressure is usually sufficient to raise a column of fresh water, weighing 8⅓ lbs. per gallon, from a drilling well. The logs of a number of deep Gulf Coast wells, in fact, will reveal that actual bottom hole pressures at depths below 8,000 ft. were controlled only with extreme difficulty with drilling fluid weighing from 12 to 16 lbs. per gallon. In one proven field near Houston, Texas, for instance, a major operator circulated 16 lb drilling fluid for 30 days in an effort to come out of the hole with 3½ in. drill pipe. Every time two or three stands of pipe were racked in the derrick, the circulating fluid started out and the blowout preventers had to be closed. The drill pipe was finally cemented in the hole, and the well abandoned. This is undoubtedly an exceptional instance of very high potential bottom hole pessure; nevertheless, when a 10,000 ft. well, with only light washing, will start to clean itself vigorously and wind up with anywhere from 2,800 lbs. to 4,400 lbs. completion pressure at the surface, the necessity for providing adequate drilling control equipment is clearly indicated.

Included in the modern assembly of pressure control equipment, along with blowout preventers, master gate valves, flow-line manifolds, etc., is carefully selected casing-head equipment and drilling-in or completion control, equipment. When the drilling bit is headed for deep producing sands, carrying high potential pressures, no weak links in the chain of control equipment can safely be tolerated.

Increasingly, today, the surface casing string is being cemented clear to the top, thus forming a rugged foundation for the erection of pressure control units. Moreover, in line with the latest practice, the top thread on the surface casing (which theoretically will never be subjected to pressure if well-designed casing heads are employed and the intermediate casing string cement job holds) is the only threaded connection used in either the main drilling control hook-up, the casing-head assembly, the drilling-in hook-up, or the Xmas Tree or completion manifold. Due to the substantial extra factor of safety afforded by flanged type equipment as compared with threaded type equipment, the use of threaded type control units on deep wells is virtually excluded. An interesting example of what can happen to threaded connections under the shock of sudden high gas pressures was provided by a blowout which occurred recently in a deep Gulf Coast field. Two flanged type pressure operated preventers of approved design were installed on this well by means of a casing nipple between the casing head and the lower preventer flange. When the well suddenly unloaded its drilling fluid, and the rams of the upper preventer were closed, a pressure in excess of 4,400 lbs. built up on the casing nipple. In view of the fact that the preventer equipment was only 3,000 lbs. test, the operator deemed it wise to install a third preventer above the two originally on the well —another casing nipple necessarily being used to make the connection. On a sudden surge of excess pressure, both nipples "belled" in the middle, collapsing the threads engaged in the flanges, and the well went wild. Illustrations No. 1 clearly reveals the lack of wisdom in relying on pipe nipples in the control of high well pressures. In some instances it has happened that the rams of the preventer, which were closed around the drill pipe when the blowout occurred, still tightly clutched the joint of pipe which extended through it at the moment the casing nipples gave away. Although these flanged type preventers of 3,000 lbs. test pressure easily held the estimated 4,500 to 5,000 lbs. shock load imposed upon them, the nipples with which they were assembled failed at the critical moment. It is interesting, in this connection, to note in illustration Figure 1 that the two lower preventers, which were flanged directly together, were blown off of the well as a unit. The flange connection was not in the least weakened by the high pressure, although sand cutting later damaged the double preventer hookup somewhat, as shown.

With the surface pipe set and cemented to the top, the next step dictated by modern procedure is to install a casing head housing on the top thread of the surface casing. This casing head usually has a female thread on bottom, and a flange on the top opening. To the top flange of the casing head is connected the bottom flange of the master gate valve, or the blowout preventer, depending upon the individual preferences of the operator. In almost all instances both a blowout preventer and a master gate valve, or equivalent, is used. In many instances a master gate valve and two blowout preventers are used. Preventers may be of the ram type; or, one ram type and one pack-off type preventer may be flanged together. The ram type preventer, usually of the pressure operated, remote control design, is relied upon for a fast, positive shut-off of the annular space between casing string and drill pipe in event of a threatened blowout. Since it is good practice to continue moving the drill pipe to prevent sticking while circulating to regain control, the pack-off type preventer may be depended upon to absorb the wear and tear while pipe is rotated and raised and lowered slowly between tool joints. In the event the sealing member of the pack-off type preventer requires replacement, the ram type preventer may be closed while this is being accomplished. A new type of pack-off preventer, designed to close automatically when well pressure is exerted on it, is being tried out in some areas. It is designed to take the place of the customary pack-off type preventer, the sealing means of which must be installed manually. As in the case of the customary pack-off type of preventer, the sealing means is used to absorb the wear and tear of pipe movement, while the ram-type preventer is held in reserve to effect a positive closure of the annular space should it become necessary to replace the sealing means of this automatic preventer.

In many standard main drilling control hook-ups, a master gate valve is used below the blowout preventers to provide a shut-off of the well bore when pipe is out of the hole. In numerous hook-ups, when only a single ram type blowout preventer is employed, a master gate is installed above so that well may be shut-in with drill pipe suspended on the rams in the event any connection between the swivel and pumps fails under pressure while a blowout is being fought. Circulation, in this event, is continued through the opening provided above the rams of the preventer. Illustration Figure 2 shows a pressure operated ram type blowout preventer installed on the surface casing, with pressure operated master valve flanged above. A pressure operated flow-line gate valve is shown flanged to flow-line outlet. Illustration Figure 3 shows a complete hook-up consisting of two manually operated ram type preventers, one equipped with blind rams; a pressure

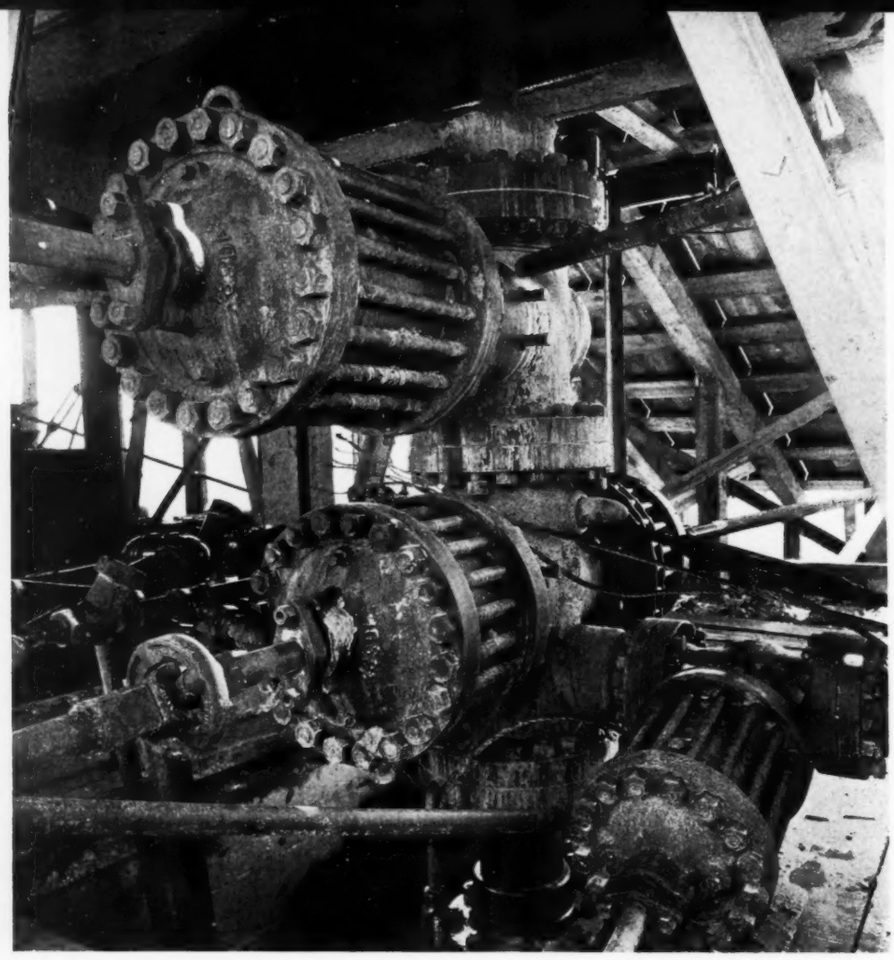


Figure 2—Pressure operated ram type blowout preventer installed on surface casing, with pressure operated master valve above.

operated ram type preventer flanged above; and an automatic preventer flanged on top. This hook-up was used on a well drilled to 12,000 ft. in lower Louisiana. In the course of drilling, it saved the well from several blowouts, one of them at 11,999.

When hole for the intermediate casing string has been completed, casing is generally run through the main drilling control hook-up and cemented. In almost all cases, today, casing heads are selected which permit running the casing hangers through the blowout preventers without the necessity of releasing tension on the casing string. If solid "boll-weevil" type hangers are used, then odd lengths of casing are employed as the string nears the casing seat to permit connection of the threaded "boll-weevil" hanger at a point in the string which enables it to seat in the casing head with the pipe just off bottom. One of the latest type of casing heads provides an ingenious slip assembly which may be passed through the blowout preventers, and which may be installed after cement has hardened and the casing string is in the exact degree of tension desired by the operator. As a general rule, it is regarded bad practice to set the weight of the casing string on bottom, due to the severe strains imposed on the threaded couplings. For this reason, types of casing heads which obviate this necessity have sprung into general use in deep well drilling. To increase safefty, all sealing members are steel, eliminating flexible packing entirely.

When the intermediate string of casing has been cemented, sealed and suspended, the drilling control hook-up is removed and a casing head spool is installed. After the casing head spool has been installed, the drilling control hook-up is replaced and hole is made for the oil string. The oil string is run and cemented as indicated in the case of the intermediate or production string of casing.

When the oil string has been cemented, sealed and suspended, the general practice today in high pressure deep fields is to remove the main drilling control hook-up, usually of 13⅜ in. size, and substitute a seven inch drilling control hook-up consisting of units comparable to those used in the assembly of the main control hook-up. Drilling-in is accomplished usually with 3½ in. O.D. drill pipe.

In order to relieve the long oil string of full formation pressure after the well has been brought in, many seasoned operators run liner and screen with a special tubing to casing packer. This packer serves to relieve the seven inch oil string of well pressure, thus minimizing the possibility of leaks or loss of control at the surface connections. Screen sizes used vary from 4¾ in. to 2⅞ in. or the same O.D. as the tubing string. Usually blank liner is run opposite the casing perforations, to prevent the screen from being cut out by sand jetting through the perforations. When a tubing to oil-string packer is used, provision is usually made in the tubing suspension head to permit carrying approximately one-half the dead weight of the tubing on the suspension means, and one half on the packer. This involves somewhat careful calculations and the use of a tubing hanger which can be lowered into the oil string while setting the packer, and then picked back up and suspended and sealed in the tubing head when the desired amount of stretch in the tubing string has been taken. Several soundly engineered and proven units of this design are available today.

As is indicated by the increasingly rapid substitution of 6,000 lbs. test drilling control equipment for 3,000 lbs. test equipment in drilling deep wells, and in the continously improved design and construction of these units, oil tool manufacturers are constantly seeking ways and means of supplementing the present high degree of control which may be exercised over the highest well pressures yet encountered in domestic fields. In the opinion of a number of practical men, it is likely that one of the next innovations looking toward more exact

Figure 1, clearly revealing the lack of wisdom in relying on pipe nipples in the control of high well pressures.

drilling control procedure will be the use of a square Kelly drilling head when approaching producing sands, or in coring breaks in deep wildcat wells. At present, all types of drilling control hook-ups are either wide open, or completely closed. Frequently, when in a danger zone, a driller will station one of his rough-necks to watch the returns in the mud ditch for evidence of gas bubbles, or gas cutting of the circulating fluid, and for changes in the level of the mud in the slush pit. Otherwise, the driller has no prior notice of a blowout until mud starts blowing up through the rotary, at which time he must act quickly to close his preventer and flow-line valves, open his flow-line choke manifold, and begin mixing and circulating heavy mud to regain control—meanwhile, keeping his pipe from sticking by rotating and raising and lowering it.

Use of a square Kelly drilling head in conjunction with a variable choke manifold controlling mud returns while drilling in high pressure zones would permit carrying a slight surface back pressure on the mud column, say 25 to 50 lbs. A pressure gauge installed on the derrick floor, and connected to the variable choke manifold, would indicate constantly to the driller whether the flow velocity of his returns were normal, subnormal or abnormal. If normal, all is well. If sub-normal, loss of circulating fluid would be indicated. If abnormal, and this is most important, early warning would be provided that the mud has become gas cut and that the well is starting to unload. This warning would be given the instant the well starts to unload, instead of as often at present, after the well is already largely unloaded. In addition to thus serving as a warning of danger, the square Kelly drilling head would also eliminate the shock and surprise attendant upon a sudden blow; and would greatly reduce the problem of closing flow-line choke discharge openings. Some such system of maintaining a positive and continuously indicating control over the mud returns is certain to be one of the near future developments in pressure control for high pressure areas.

The above discussion has been confined entirely to operations where mud is utilized as the circulating medium. While mud will doubtless continue for some time to come to be the most common circulating medium, drilling-in with oil is becoming more and more prevalent, even in areas where the closed surface pressures, after completion, approach 2,000 lbs. per square inch.

The control equipment used when drilling with oil is usually the same as that customarily used when drilling with mud, save for the addition of the square Kelly drilling head, or means for packing off around the Kelly during rotation. This latter equipment, like other control equipment, is undergoing rapid improvement. An adjustable surface choke controls the pressure on returns, while a gauge on the return line ahead of this choke serves to indicate whether the circulating column of oil is feeding back into the horizon being drilled, or whether the horizon being drilled is producing into the circulating column.

In the limited scope of an article of this nature, it is impossible to touch on the numerous supplementary phases of pressure control, such as the several ingenious types of flow-line manifolds designed to permit quick closure of blowout preventer flow-lines by means of pressure operated gate valves; bleeding of returns through chokes while circulating to regain control of the kicking well; special high pressure manifolds prepared for quick connection of Halliburton pumps in the event of necessity to introduce circulating fluid into the well under higher pressures than can be built up by the compounded slush pumps; special manifolds which permit quick compounding of slush pumps in an emergency; double stand-pipe manifolds, removable float valves, etc., etc. Summarizing these briefly, recent developments in pressure control equipment for drilling wells either with mud or with oil may be said to have been principally along the lines of the utilization of heavier equipment, of the use of flanged rather than threaded control units, of the use of remote, pressure operated units rather than manually operated units, and now point towards the use of a positive control over returns which will permit both the use of a gauge to indicate increase or decrease in the velocity of returns and to facilitate the application of control measures.

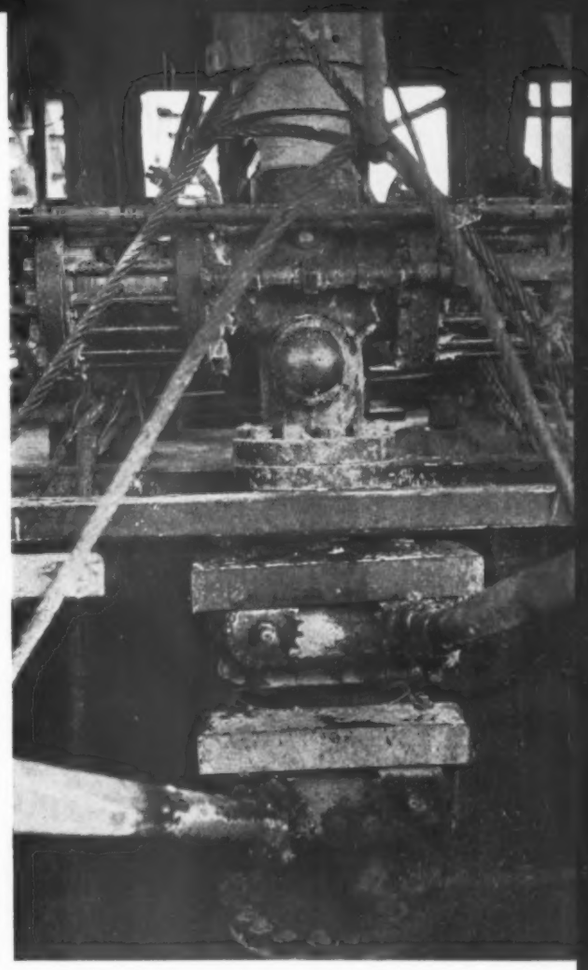
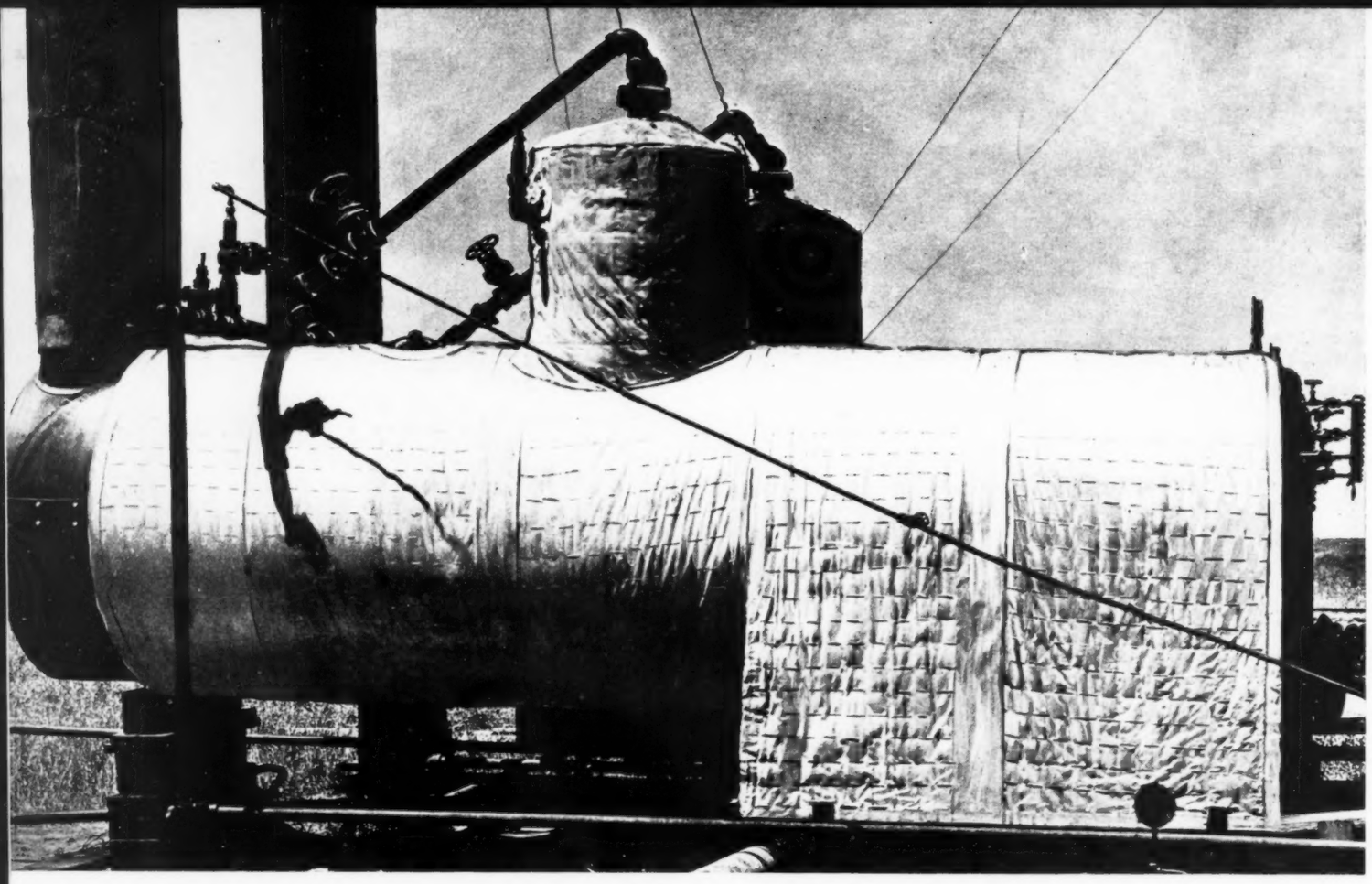


Figure 3—Complete hook-up used on a well drilled to 12,000 ft. in lower Louisiana.



Flexible-blanket insulation is made up in sections easily applied and removed in the field. It withstands a great deal of hard usage in addition to substantially reducing heat losses through radiation and convection.

MODERN TRENDS IN SURFACE DRILLING EQUIPMENT

In analyzing the development of drilling machinery over the past few years it is possible to form a more or less composite picture of very definite trends. Some of these had their beginning a long way back, but only within a comparatively short time have the ideas of a few far sighted men crystallized into methods of manufacturing equipment and procedure in using it that can definitely be pointed to as a trend, proceeding definitely toward meeting the drilling requirements of tomorrow.

Prior to 1928 and the introduction of the unitary draw works, surface equipment underwent very few radical changes, and depth records were set only by using the greatest care in handling equipment considerably over its rated capacity.

With the industry's acceptance of the unitary draw works, about 1930, a period began during which the industry has called for heavier and heavier equipment. The time between 1928 and 1932 is noted for its experimental characteristics in deep drilling. The long envisioned 10,000 ft. depth was reached and producing companies envisioned the time, now upon us, when numerous wells would be producing from this depth. Theoretically they braced their feet and in so doing they moved the manufacturer to build equipment for 300 ton loadings. At the same time numerous experiments were conducted in high rotative table speeds, straight hole drilling and experiments with mud and cementation.

The peak of this heavying up and experimentation period reached its climax about 1934 or 1935. Certain axioms of deep drilling having been established, development took place along different lines, using the established axioms as points of departure. This applies generally throughout all phases of drilling operations.

Apart from deep drilling an interesting development that came into being shortly after the advent of the unitary draw works was the so-called portable drilling unit. Portable draw works mounted upon Athey wagons were in use as early as 1924, but they were cumbersome and their span of life was relatively brief. Up until about 1930 the shallow fields, as we now know them, were drilled with light knock down types of draw works as the general rule.

In days gone by the operator had a very limited field of machinery to select from and the result was that much of the equipment in use was considerably heavier than was necessary. Now, with a vast array of modern unitary types of machinery, it is possible for the operator to select equipment for the exact rated depth to which he wishes to drill.

In the belief that the peak weight of draw works has been reached for the time being manufacturers are devoting special attention to refinements. A recently developed draw works is a case in point. While standard in type it employs a 10 in. maximum diameter chrome nickel alloy forged drum shaft and 9½ in. carbon steel forged steel line shaft and jack shaft. Noteworthy is the drum shaft construction which has been stress-designed to take care of torsional loadings where they occur, as against the obsolete designs where shafts were placed through a drum with no thought other than of shearing. In other words, under the center of the drum is the largest diameter to take care of bending. Under the low clutch where the worst

shock loads occur it is 9⅞ in. and under the bearings, when it has the strongest support and no torsional stresses it is 7½ in. The various steps in the shaft allow for complete disassembling of the drum without disturbing the bearing races. All sharp cuts are filleted to distribute stresses.

The drum of this draw works is 32 in. in diameter and 47 7/16 in. long and grooved to take up to 1¼ in. wire line. Brake rims are 54 in. in diameter and brakes are multiple lever high pressure type. Cooling is by a water circulation system within the rims, each rim having its own system.

The controls for the hydromatic brake and circulation systems, together with the lubrication arrangement, are all brought within hand reach of the driller.

The overall weight of this draw works, without wire line, but including chain on guards, is approximately 20 tons.

A recent radical change in draw works design has been made by one manufacturer employing cut gear transmission drive for all speeds. By using external band type clutches, air operated through four way valve, the shock of speed change has been eliminated permitting instantaneous changing of drum speeds upwards or downwards without shock. This type of draw works has been tested in the field for the past two years and is now being manufactured.

While the heavy draw works were being developed, and also tying into the advent of the unitary types, a movement has been found to satisfy the needs of the operator with shallow areas to drill. Along about 1929 and 1930 these operators had refined their actual drilling methods to the point where moving and rigging up required as much or more time than drilling the well. For some time prior to these dates certain manufacturers of pulling and well servicing machines had been adding rotary attachments to light hoists for the very shallowest of work. It was not long, however, before the pressure from the operators brought forth heavier units of the portable and semi-portable class. To fulfill this demand, the pulling machine manufacturer designed heavier and heavier machines, and the manufacturers of standard draw works created new models for light service.

Popular units of this type widely used in drilling up to 4,000 ft. with 3½ in. pipes are small conservative models of the larger draw works. They have integral mounted sand reels on the line-shafts, automatic catheads, chain lubrication systems, centralized alemite connections and high pressure brakes. They can be truck or skid mounted and can be direct driven by a variety of gas, Diesel or steam combinations of transmission drives in units of one, two, or three power plants.

A late development in this series of models deserves special note as it is considered by many operators and contractors to be the ideal exploration type of draw works. It is capable of drilling from 6,000 ft. to 8,000 ft., and thus fits into the typical wildcatter's picture.

This draw works was the first of its size to use 2½ in. pitch roller chain and cut tooth sprockets, allowing for extreme compactness of design, and is considered by many operators to be the largest wherein it is economically possible to use a sand reel mounted integral with the unit, on the line shaft, due to excessive weight and distance back of the catheads on larger sizes of draw works.

This draw works has all the modern features of the larger machines, yet is light and compact. Its weight is 16,000 lb. complete with chain and guards. It is capable of taking 600 h.p. input either through a steam drive or transmission hook-ups.

In the rating between 7,000 and 9,000 or 10,000 ft. are what may be classed as medium draw works. Due to a great divergence of operative practices at these depths, it is difficult to state definitely the depth to which a draw works can drill efficiently. Usually a greater amount of care is exercised in drilling as the hole progresses in depth, and for this reason the manufacturer has to place a drill pipe limit on his product. A medium draw works should be classed as being capable of handling 5,000 ft. of six-inch pipe, 7,000 ft. of 5 9/16 in. or about 8,000 ft. of 4½ in. pipe. However, 10,000 ft. could be reached with smaller pipe.

Generally a medium draw works employs a 7½ in. chrome vanadium steel drum shaft, and should have a bearing capacity to match the torsional strength of the shaft. One well-known manufacturer employs a bearing with a life capacity of 57,000 lb. at 300 rpm, and 154,000 at 15 rpm, which multiplied by the number of lines, gives the life load capacity.

Under the classification of heavy draw works come the machines that are capable of drilling to depths in excess of 10,000 ft. Units of this type designed to drill consistently to 10,000 ft. have been reaching that and even greater depths in California, the Gulf Coast, the Mid-Continent, Louisiana and a number of fields outside the United States. Its record depth is in excess of 11,000 ft. Another model meets the demand for a lighter piece of equipment which is still capable of consistent 10,000 to 12,000 ft. work.

TRANSMISSION DRIVES

One of the most interesting developments in power transference of recent years has been the several trends of transmission drives.

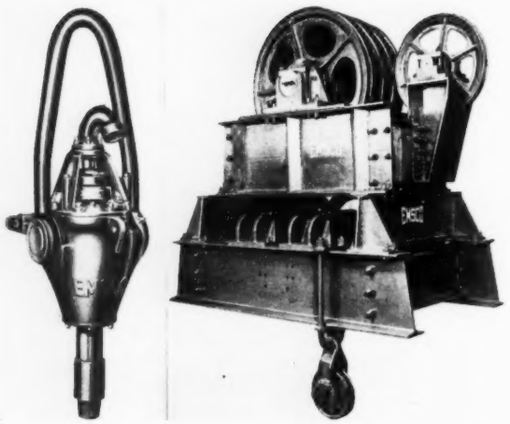
During the pioneer days of the early portable draw works, manufacturers used only one engine behind a draw works, and drove with chains through a reverse and friction clutch. This was fairly satisfactory and is used today to some extent, but it did not allow for a stand-by unit in case of a power breakdown.

One of the first manufacturers to employ twin engines used a gear transmission to utilize the power of both engines. They also drove the pumps from this type of hook up. From the transmission the drive operated through a reverse and friction clutch to the draw works.

The newest developments of twin and triple engine drives have been the V rope and chain transmissions. In these forms of drive, the engines are lined up side by side directly behind the reverse gear, the chain transmission enabling the engines to be compounded either to the draw works through a reverse and friction clutch or to the pump taken, usually, off the rear engine shaft.

This type of drive with the chains operating in a closed oil-flooded case has provided a very compact and popular method of drive. The substructure for the engines, transmission and reverse and friction clutch

Six wheel International truck at work in the East Texas field near Kilgore.



Modern type rotary swivel and crown block.

can be broken down according to the operator's ability to transport the units. Again, the ground plan of the foundations shows a considerable saving of occupied space, and due to the character of construction it is only necessary to set the unit upon sills or a mat of wood.

The drive from the transmissions to the draw works consists almost universally of chains. This allows a great variety of draw works placement schemes. One popular type has the draw works on the same skids as the rest of the transmission and the other places the draw works up on a 10 ft. high structure, with the transmission on ground level.

The three engine transmission is an interesting development. It was evolved from two different operation requirements, the first being the operator's desire to compound two pumps, and the second to be able to add a third engine if the well reached a depth not easily handled by two engines.

With two-engine drives it is not feasible to compound pumps due to horse power limitations. A second standby pump can be used with a conventional drive, however. Often an operator chooses to have a pump driven from one of the two engines, and a second pump, separately driven by its own engine as either a standby or for compounding. With the three-engine transmission, this pump engine can be placed in the train for deep drilling or for setting a long string of casing.

It might be added here that the transmission drive has been turned for use with two vertical steam engines. This allows one engine for the draw works and one for the pump, or both engines for hoisting. The result is a great economy of steam.

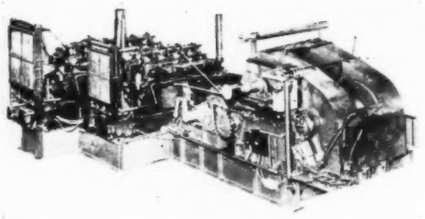
ELECTRIC DRILLING

Approximately ten years ago the first full D.C. electric drilling outfit was used. Very few were sold until three years ago, since which time they have come into some prominence. Such a hookup consists of either gasoline, gas or Diesel engines driving directly to D.C. generators, which in turn drive an electric motor to accomplish the drawworks drive and also to a motor to drive the slush pump or pumps.

A great many different schemes have been worked out and a number of these have been employed in the field. The most popular seems to be an outfit consisting of two full Diesel engines, each driving a D.C. generator, so arranged that the power of either or both generators can be employed on the D.C. motor driving the draw works or the pump or pump motors. By such a hookup ample power is available to come out of the hole which naturally is greatly in excess of that needed to revolve the table under ordinary conditions.

The use of full electric drilling power is perhaps better suited to marine drilling activities than any other type of equipment. Power generating plants are constructed on barges and may readily be moved from location to location where flexible electric conductors transmit the energy to draw works and pump motors. The advantages are present whether the wells are drilling on foundations of piling or on drilling barges.

The characteristics of D.C. current are very desirable for driving a draw works as these characteristics approximate the flexibility of steam. There are no serious objections to driving a slush pump with an internal combustion engine, however, as the speeds are more or less constant and there are no reversals. Consequently, what is known as the electric-mechanical hookup has come into some prominence.



Dual motor drilling unit consisting of unitary draw works, reverse and friction clutch air actuated, and Diesel-driven pump countershaft for driving two slush pumps—courtesy Emsco. Fully enclosed rotary drilling machine of current design.

A typical outfit of this kind consists of two internal combustion engines driving into a totally enclosed compounding transmission case arranged in such a manner that either or both of the engines can drive a D.C. generator to generate power for running the electric motor to drive the draw works, or both of these same motors can drive into a slush pump or pumps through the transmission case. To date the first cost differential between electric-mechanical and full electric drive hook-ups has not been wide enough to justify the lack of uniformity and flexibility.

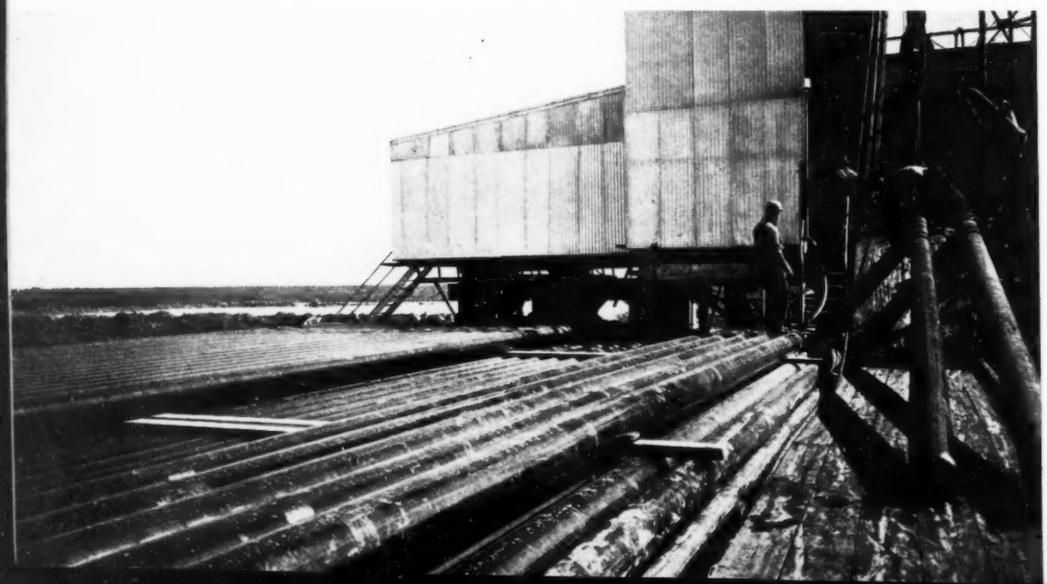
MUD PUMPS

The development of mud pumps has gone generally hand in hand with the increase in sizes and capacities of drilling units, and like drilling units a peak was reached and a period of improvement in design set in. Expressing the deep drilling contractor's desire for fluid, and lots of it, pumps have been designed for handling great volume at up to 3,000 lb. fluid end pressure and 250 to 350 lb. steam pressure.

In constructing these large pumps certain improvements have been made, such as the introduction of molybdenum cast steel fluid ends, piston steam valves and a general strengthening of the basic design.

A leading equipment manufacturer recently came out with a power driven slush pump in one size, (7¾ in. by 16 in.) wherein the fluid end is entirely of forged steel, built in sections and welded, instead of the established cast steel practice. The valve chambers are separate forgings and the cylinders are built in two sections each. All suction and discharge manifolds are forged bends instead of cast steel. The advantages claimed are that the construction is lighter

Development of alloy steel tubing has advanced to the point where drilling of wells below 12,000 ft. presents no drill pipe or casing difficulties—courtesy A. O. Smith Corp.



in weight than the usual castings and increases the ability to effect repairs to the fluid end by welding.

ROTARY TABLES

Rotary tables reached their peak in size some years ago with the introduction of the table with a 27½ in. opening. Since then the large tables have been totally enclosed and oil bath lubricated and lately equipped with spiral bevel gears. They represent a great deal of weight, and since many operators have reduced their surface pipe to smaller than 20 in. the need for the large table has diminished appreciably.

It was found, therefore, that a much smaller table could be used, providing the rotative capacities could be kept up to the point where long strings of pipe could be handled. This led to the development of the 20½ in. table for this purpose. It uses cone roller bearings which not only have a high load rating but are more readily adaptable to load at greater speed than other types.

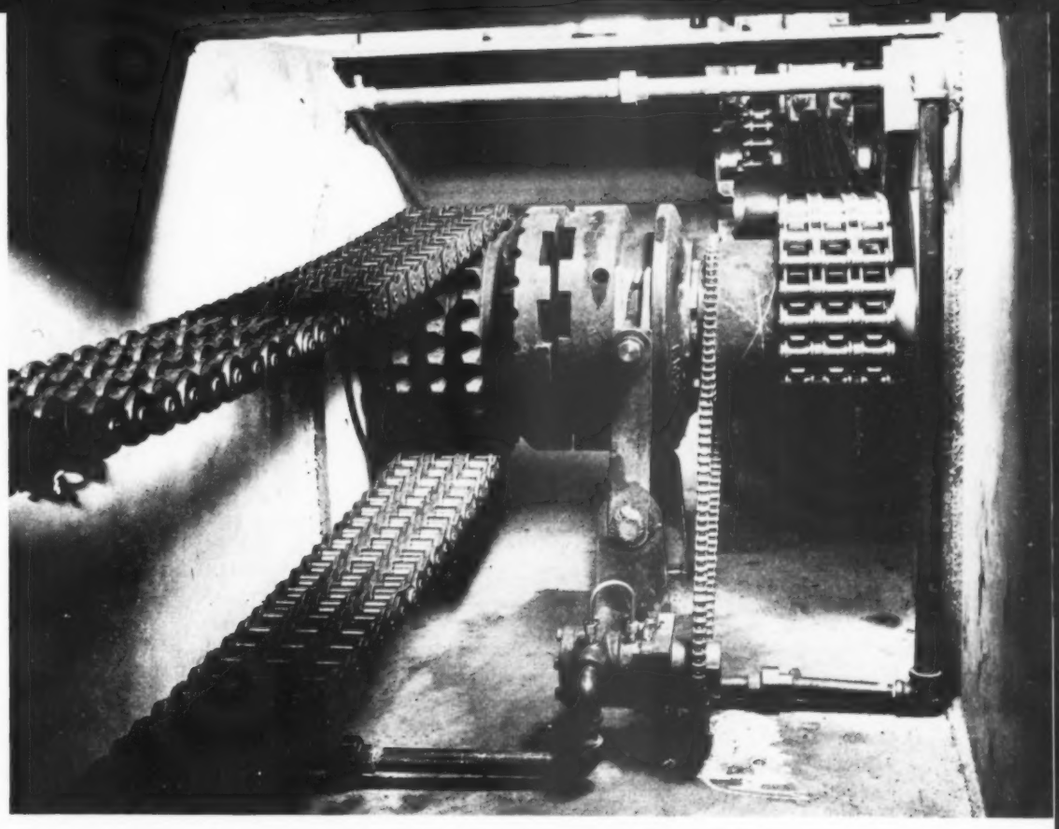
A new point in the construction of tables has been the elimination of cast steel in the construction of the base of the table just described. The base is one piece of fabricated weld construction and completely annealed after manufacture. The design creates a base with a dead load capacity of the larger tables yet is a great deal lighter.

The table is equipped with oil bath and central alemite lubrication, has complete table seal and with spiral bevel gears permits quiet operation.

BOILERS

From the earliest days of oil drilling, steam has been the most prevalent motive power of drilling equipment. With the expansion of operations and with tens of thousands of wells being drilled each year, other prime movers have appeared on the scene. Where water conditions are good or even tolerable, steam retains its ascendency in the United States, among other reasons because of the reluctance of operators to scrap expensive equipment. In many old fields and most new ones outside the United States there is a gradual but definite trend toward Diesel drilling power.

The steam boiler industry is constantly forging ahead in order to supply the trade with boilers of ample capacity for the hardest jobs. Oil country operations require boilers of simple and rugged construction, combined with compact assembly to permit repeated handling and moving. These features are best produced in the locomotive type boiler. Other boilers have been used in oilfield work, but without the enduring favor of the locomotive type.



Emsco portable drilling machine with reverse gear and drilling transmission.

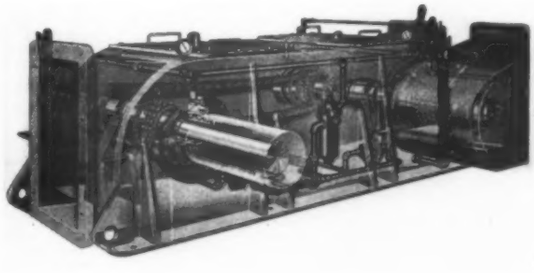
For many years the 25 h.p. oil drilling boiler was the standard size. This boiler had a short firebox seldom over four feet long. The diameter of the barrel was reduced to the inside width of the firebox and a tapered connection piece joined barrel and firebox end together. With this construction the steam space was restricted; therefore a large steam dome was used and the logical place for a large dome was over the widest part or the firebox end. The water space around the firebox was continued around the bottom with a restricted opening for the fire grates; hence the name of waterbottom or wet bottom. This boiler was built for 100 lb. working pressure and weighed from three to three and a half tons.

Around the beginning of this century larger boilers came into demand. Sizes were first increased to 30 and 40 h.p.; working pressures stepped up to 125 lb. By the early twenties the trade was supplied with boilers up to 75 h.p. for working pressures of 150 to 175 lb., weighing up to eight tons. By that time the A.S.M.E. boiler construction code received recognition. The demands of this code and the larger boiler sizes brought about a change in the stereotyped designs. Boilers were now built with straight barrel and the dome placed on the barrel. Lively controversies arose about the dome location until it came to be agreed that the location of the dome had no effect on the steaming qualities.

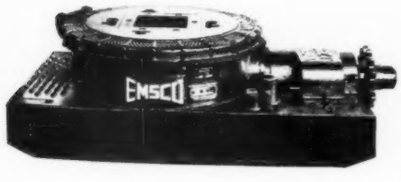
A quick change took place with deep drilling operations of the late twenties. A demand arose for boilers of 100 to 125 h.p. first for 250 lb. working pressure, later for 300 to 350 lb. These pressures made the old waterbottom construction impractical and the open bottom boiler appeared with the entire firebox open at the bottom, held to the outside wrapper sheet by a heavy forged steel mudring. This also gave increased space for grates or burners.

Increased firebox sizes were then recognized as stepping up boiler efficiencies. Fireboxes were lengthened to 84 in. and lately to 96 in. or even 98 in. on the largest sizes weighing from 18 to 20 tons. By now the steam space above the water level was sufficient to use a smaller dome. Boilers

Totally enclosed oil bath lubricated drilling transmission with dual oil pumps—courtesy Emsco.



Fully enclosed rotary drilling machine of up-to-date design.



Exploratory drilling in Oklahoma with portable rigs reduces operating costs appreciably—courtesy Franks Mfg. Co.

without dome have appeared, on which the steam take-off is inside of the barrel, about 10 in. above the waterline. It is claimed that this method gives sufficiently dry steam, but others maintain that a dryer steam is going in the line when taken off not less than two feet above the water level, which in oil country boilers is usually very turbulent. One boiler has been brought out recently with a dome about 20 in. high, having the steam outlet on the front of the dome, slightly over two feet above the water level. The low overall height facilitates handling and moving and gives a neat streamlined effect to the setting.

A new feature in boiler construction has been the replacement of riveted joints by fusion welding. This construction eliminates several hundred rivets, besides many overlapping plates and straps, all of which are possible sources of leaks. It lowers the boiler weight almost 10 percent, and the smooth surfaces make for easier handling, cleaning and washing.

SUPERHEATER

Steam-saving equipment is now in general use in oilfields throughout the world. All but a few of the most recent developments have been described in WORLD PETROLEUM. The use of a vertical twin steam engine with hand-controlled variable cut-off for the slush pump drive is such a common sight that it is no longer news. Its widespread adoption is easily understood when its importance as a steam-saver is realized. This one item effects a saving of approximately 35 percent. The vertical twin steam engine has also come into general use as a direct prime mover for the rotary and is effectively reducing steam-consumption as compared to the conventional rotary drive by means of the big hoisting engine.

The open-type feedwater heater pump has proved its advantages so conclusively over the past few years, that it is now standard equipment on the steam rigs of many operators both large and small. It not only preheats the feedwater but also condenses exhaust steam and thus substantially reduces water consumption as well as fuel cost.

In line with the development and acceptance of this steam-saving machinery, high steam pressures and superheat have come into more and more common use. The swing to higher pressures has resulted in improved performance without the necessity of going to very large cylinder diameters. Superheat also has played an important part in stepping up performance by reducing pressure drop in the steam line to the engines and delivering dry, full-pressure steam to the cylinders. Superheating increases the specific volume (cu. ft. per lb.) of steam. This means greater power output from a given quantity of water evaporated or a saving in fuel.

It is of interest that while much was being accomplished in the way of feedwater heating and more efficient use of steam, the oil-country boiler merely continued to grow bigger and bigger. Certain improvements were made in construction details and a constantly increasing proportion were built for high pressures (300 to 350 lb. per sq. in.), but prior to 1937 there were no developments resulting in substantially improved steaming characteristics.

In October of last year a leading manufacturer of steam-saving equipment introduced a portable superheated steam generator, incorporating an advanced and somewhat revolutionary design for oilfield power plants. Contrary to the then-existing trend, this new development was actually a step toward smaller size and reduced heating surface. Here at last was a unit designed for more effective use of heating surface rather than for increased output by means of increased size and weight.

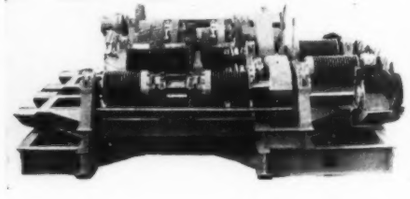
This portable superheated steam generator is essentially a boiler of large-firebox, short-tube construction combined with a newly developed smokebox superheater. The fire tubes are only eight feet long and the total evaporative heating surface is slightly less than 700 sq. ft. Superheating surface is approximately 250 sq. ft. and maximum working pressure is 350 lb. per sq. in. The entire assembly is a self-contained unit mounted on steel skids for portability. Complete steam piping is provided, including valves and piping for by-passing the superheater.

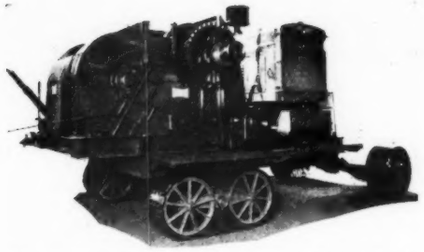
High steaming output per unit of weight and per unit of heating surface is accomplished by using short tubes and thus making every square foot of heating surface highly effective. Tests have proved that heating surface of tubes is much more effective at the firebox end than at the smokebox end, and that with the usual draft conditions available, the last four to six feet of tube bank in boilers having tubes 14 to 16 ft. long are of no benefit from a steaming capacity standpoint.

The reason for the increasing length of tubes in recent years is explained by the long-established practice of rating oilfield boiler capacity nominally on the basis of 10 sq. ft. of heating surface per horsepower without regard for effectiveness of heating surface. By this method of rating, the relatively useless tube heating surface at the smokebox end of a very long barrel counts just as much as the extremely effective firebox heating surface. The manufacturer of the portable superheated steam generator disregarded nominal rating and considered instead actual steaming capacity.

With tubes only eight feet long the gases enter the smokebox at a relatively high temperature. The heat energy is not wasted, however, but is used for superheating. Baffles in the smokebox superheater direct the gases in counterflow. After giving up heat to the steam in the superheat elements the gases are exhausted to the stack at a

Turney four speed drilling unit, showing geared transmission—courtesy Petroleum Machinery Corp.





Emsco portable machine on Athey wheels.

temperature actually lower than the temperature of the steam leaving the superheater. The effective utilization of hot smokebox gases for superheating results in the portable superheated steam generator maintaining a high degree of efficiency when operating at a high percentage of its rating.

The first opportunity to check the performance of a portable superheated steam generator in actual oilfield service was presented near the end of 1937. Heavy-duty rotary equipment was moved onto a deep test in northern Pennsylvania with a single steam generator to supply all requirements. This one unit in cold winter weather and without the benefit of insulation performed a really man's size task in maintaining full pressure while drilling with four inch drill pipe to a depth exceeding 8,000 ft.

Tests made while drilling showed that with a net evaporation of 9895-lb. of water per hour the portable superheated steam generator was operating at approximately 530 percent of its nominal rated capacity as based on 10 sq. ft. of evaporative heating surface per horsepower. This high rate was maintained with the atmospheric temperature only 15 deg. above zero, and with a high wind velocity.

Although in recent years there has been a swing to fuel and feedwater economy through the application of steam-saving machinery, the saving in fuel consumption that can be effected by boiler insulation has been overlooked by most operators. Heat losses by radiation and convection are costly. Conclusive tests show that substantial savings can be made by a relatively small investment in proper insulation.

Believing that the general use of boiler insulation had been retarded by the cost of keeping insulating material in repair when rigs were moved, a manufacturer of steam-saving equipment recently introduced flexible-blanket insulation. It consists of blanket sections which are handled in convenient rolls and are wrapped around the steam generator or boiler. Adjoining sections are laced together by means of telegraph cord and reinforced eyelets.

Flexible-blanket insulation is resistant to the deteriorating action of both heat and moisture. Each section comprises an inner sheet of strong wire-inserted asbestos canvas, a filling of mineral wool and an outer covering of weatherproofed and mildewproofed wide-numbered duck.

This past winter a major operator in East Texas made tests of 13 days duration before and after installing flexible-blanket insulation on two boilers and noted an 18 percent saving in fuel consumption.

An observer of trends in rotary drilling equipment during the past two years is bound to have noticed the rapidly increasing popularity of the vertical twin-cylinder steam engine, particularly in the smaller sizes which are now so widely used for slush pump service and direct rotary drive. A comparatively recent development is the combination of two relatively small engines into a portable double engine drive.

The double engine drive consists of two vertical steam engines mounted in line with power take-offs on a single skid-type structural base to form a self-contained prime mover plant for an entire rotary rig. The steam manifold, control equipment and clutches are arranged so that in regular drilling service the engines operate independently—one driving the power slush pump and the other driving the rotary—but for heavy-duty hoisting are clutched together and operate as a single prime mover. Hand-controlled variable cut-off and efficient size (7¾ in. by 7 in. engines are most widely used for this application) in relation to load assure utmost economy.

BLOCKS

Crown blocks and traveling blocks, grouped together, represent equipment that to the inexperienced should be as simple to construct as their operation and function is easy to define in the scheme of drilling a well. The demands of operators, however, never leave the manufacturer to his own devices for long, and the result has been that crown blocks and traveling blocks have presented a continual problem to the alert manufacturer.

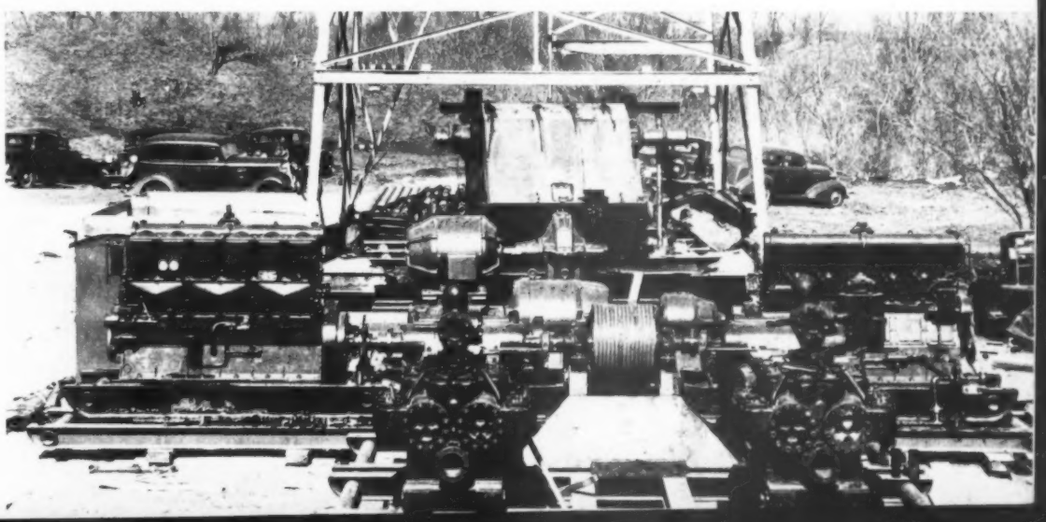
Originally the crown block was merely a nest of casing sheaves set in grooved wooden beams. Then the bronze bearing and steel beams were introduced and later the roller bearings. With these nests of sheaves set all on the same level there was not only the problem of stringing lines, but it was impossible to increase the sheave size to eliminate excessive wear of lines, due to the spread of the lines. The solution of the two problems was to mount the casing sheaves on one level and the sand and crown sheaves on another. The so-called double deck block came into being in 1923-24 with the sour-belly arrangement of sheaves, consisting of a group of 30 in. sheaves mounted in a straight line with beam members swung underneath to support the sand line sheave over the center of the hole.

From this idea developed the so-called California type of double deck block. This block consisted of a lower deck having two small diameter casing sheaves, the sand line and derrick line sheaves. Large 40 in. to 48 in. diameter fast sheaves were placed above this lower deck. This type of block was made by many manufacturers using a variety of bearing applications and sheave placements, but all having the same fault of creating an excessively heavy and cumbersome block to rig up.

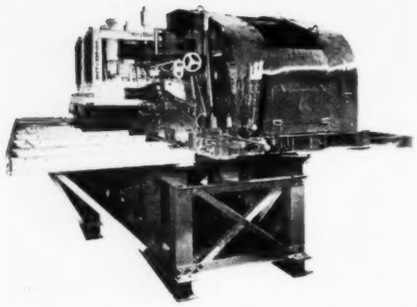
Traveling blocks for a good many years underwent no changes to speak of, until 1925 when the solid cast steel smooth sided side-plate was introduced to replace the projecting side bars and clevis bolts so objectionable and dangerous when handling pipe at high speed. This method of construction has now been adopted by most manufacturers, with but few refinements.

At the same time when the California type crown block was winning its popularity, there developed in the Mid-Continent a demand for a single deck block with the sheaves mounted in line, reflecting back to the original double deck principle, but minus the beams for sand and derrick line sheaves. With this type of block a small diameter derrick line sheave is swivel-bracketed to the underside of the block and a sand line sheave is bolted to one side of the main support members.

As the operator required more tonnage capacity, and as they increased the size of wire line, it was necessary to construct blocks with larger sheaves, larger bearings, and generally heavier construction. This led to very cumbersome and heavy blocks—the traveling blocks in particular being so wide that with a long string of pipe racked in the



An Atlas-Richards hook-up. The draw works is driven electrically, power being supplied by Texrope driven generator.



Dual motor drilling outfit consisting of eight-speed draw works, reverse and friction clutch —courtesy Emsco.

rig a positive danger was manifest and round trips slowed down.

One manufacturer specializing in this equipment has used for a long time a staggered sheave arrangement which made it possible to create a narrow traveling block.

Just recently another equipment company has developed a combination of the so-called Black blocks. These blocks, the crown and traveling, employ a new principle of bearing application. Instead of using the conventional sheave with its periphery a great distance from the bearings, necessitating wide bearings to distribute overturning loads, this scheme uses a sheave that is simply a rim of manganese steel with a ball race cut around its inner surface. Instead of a shaft or pin of any kind, a large diameter hub is used with the corresponding inner ball race cut thereon. This construction does away with all spacer plates and presents a low overturning factor for the sheaves. The result is a traveling block equipped with five 50 in. diameter sheaves only 22 in. wide. The corresponding crown block with six 50 in. sheaves is narrower than some older types, having only four 42 in. or 48 in. sheaves.

ROTARY SWIVELS

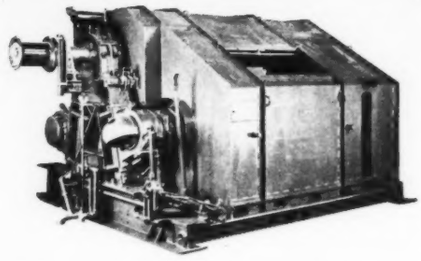
The rotary swivel is one item of the rotary drilling equipment which is called upon to do more than its share of the work. Practically the entire weight of the drilling string is revolving on the main bearing of the swivel. Of necessity, the swivel must be kept to more or less small proportions as it has been found that extremely heavy swivels sufficiently large to employ bearings to handle adequately the drilling string load at high speeds and to give long life to the bearings are so heavy and bulky that their use is not only dangerous but tends to cause the kelly to bend or kink. Consequently, as drilling loads increased and as revolving speeds have steadily grown faster until they now in some cases have reached 400 RPM., it has been necessary to refine the design of the swivels very materially to incorporate the best bearings available and to increase the oil capacity, to design so that the bearings are at all times submerged in oil, and to provide a means for cooling.

Very elaborate tests have been made by the manufacturers of swivels to determine the relation of speed and load to the life of the main bearing of the swivel.

In a bulletin recently published by a leading equipment manufacturer is included a chart known as the average life factor chart which is constructed with reference to rating load and speed of the swivel bearing which is rated at 215 tons at 100 RPM. With the average operating load, which will probably be two-thirds of the rated load or 143 tons, the life of the bearing is 3.5 times that at rated load. With the speed doubled, the life is reduced to one-half. With the speed reduced to one-half, the life is doubled. Also, when the load is doubled, the life is reduced to one-eighth. When the load is reduced to one-half the life is increased eight times.

From the above it will be noted that the rotary swivel is indeed a problem, especially when operators are drilling to greater and greater depths which means more weight on the swivel while in many instances it is desired to speed up the drilling in order to obtain a straighter hole.

The swivel above referred to is designed for drilling to depths of approximately 10,000 ft. This swivel weighs 3250 lb. and the oil capacity is 18 gallons. This is not the largest swivel being offered to the trade. Another designed for deep drilling, weighs 6,500 lb., is rated at 300 tons at 100 RPM. and the oil capacity is 53 gallons. There are larger swivels made by several manufacturers. At the moment it looks as if there will be a demand for a swivel capacity that will permit drilling economically to depths of approximately 15,000 ft.



Emsco unitary draw works with water cooling system, hydromatic brake control and controlled chain oil lubricator.

It is believed that all that can be done with the design, lubrication and bearing materials has been accomplished and it will be necessary that still larger swivels be designed for use in extremely deep wells.

DERRICKS

The steel derrick, together with substructures or underpinning and other steel appurtenances now in use, is an evolutionary development. As the drilling industry has absorbed the ideas of the steel designer and manufacturer showing the superior qualities of steel as being really permanent, therefore being more economical over a period of time, the idea of all steel units has been generally accepted.

The use of larger and heavier drilling machinery is being reflected in the adoption of taller and heavier derricks. Whereas the 122 ft. derrick was the most generally accepted height of ten years ago, 136 ft. for the past six or seven years has been a necessity in a major way, and now heights of 164 ft. and 178 ft. are in common use with a definite trend toward considering even greater heights; however, there does seem to be a limit in derrick heights that should not extend beyond 185 ft.

A factor that is influencing the trend toward the taller derrick, aside from the increasing sizes of equipment, is the present trend in the use of longer ranges of drill pipe with the consequent taller stands that must be accommodated in the derrick. The drilling industry, however, has not accepted generally longer stands as an economical practice, and it is necessary to look to the future for guidance as to the extent to which derrick heights will be governed by drill pipe lengths.

Apart from valuable refinements toward safety and economy that have been applied to steel derricks, it appears that the outstanding contribution to the composite is the very practical and now essential system of columns and bracing supporting the drilling derrick, in a manner to accommodate the cellar hookup of blowout preventers and manifolding, and commonly termed the derrick substructure. Manufacturers and drilling operators are now working together to establish standards,

Low dome boilers with fusion welded barrel, dome and firebox in a Gulf Coast field, Texas— courtesy Continental Supply.

for derrick substructures. At the time of writing definite standards are in effect covering Mid-Continent practice.

Further appurtenances, formerly constructed of wood, combining to complete the modern installation, are the all steel supports for the draw works and one might say of today's intricate prime mover group, universal unit type casing racks, walkways and tool platforms.

PORTABLE RIGS

While deeper drilling and the handling of greater weights and pressures has brought about the evolution of high-powered equipment, striking progress has been made in quite another direction through the development of portable rigs for rapid and economical drilling where conditions are not too difficult. While the light portable had its first use in areas where water was scarce, expensive or unobtainable, and for drilling small holes in exploratory work, its capacity, speed and economy soon widened its field so that now it is used for a large amount of straight development work.

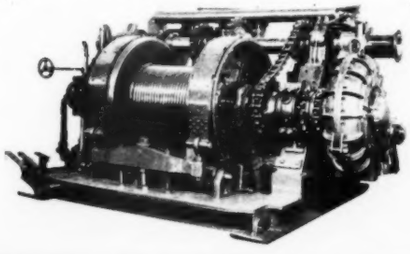
The light portable rig may be called the poor man's friend though major oil companies have employed it extensively. Every thousand dollars by which drilling costs can be reduced means so much less permanent investment on which a return must be earned. With production restricted so drastically, introduction of all possible savings in cost is important.

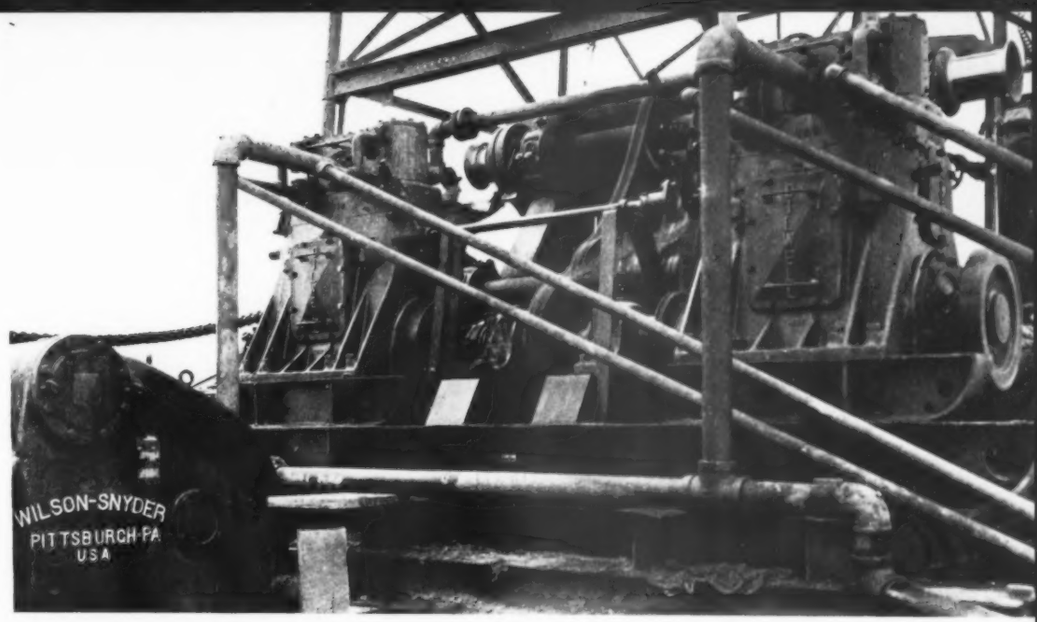
Within the past two years certain developments have occurred which contribute materially to more economical drilling. One of these is the sinking of small diameter holes or slim hole drilling. In the Mid-Continent wildcat blocks have been drilling with 6¼ in. bits and setting 4½ in. light weight casing, producing through this pipe with casing pumps. Here savings have been effected against seven inch OD oil string and 2½ in. tubing in excess of $5,000 per well with an additional saving in water and fuel of 33 percent over the larger hole.

By the use of inserted joint casing in the 6¼ in. drill hole, 2½ in. tubing may be run. This allows potential testing equal to large cased holes, although 1,800 bbl. per day have been produced by casing pumps through 4½ in. casing. The insert joint casing also permits the use of the gun perforation method of completion. Where electrical logging is possible, setting the insert casing to the final depth permits gun perforating and stage testing in the usual manner.

Another development came about through intensive water flooding of shallow

Unitary draw works with multiple clutch and ten-inch drum shaft—courtesy Emsco.





The steam engines of this portable double engine drive operate individually for driving the pump and rotary, and are clutched together for hoisting.

production, wherein several major oil companies cooperated with certain manufacturers in the building of small hydraulic feed 100 percent portable rotary units.

The problem here was to develop a machine with coring facilities to make fast hole in hard rock as well as soft formations. It had to be one that could be rigged up in the minimum amount of time and, of necessity, be portable, carry its own derrick, hydraulic feed, rotary table, swivel, kelly, draw works and power. A great many of these smaller units were built. In one field 550 ft. wells were drilled and cored in less than twenty-four hours, representing a cost per foot, all items of expense included, of from forty to fifty cents. This, when compared to the minimum contract price in the area of from $.75 to $1.25 per foot with spudder, and the additional expense of coring at $2.50 per core foot, would amount to a saving of better than 50 percent by the use of these small portable rotary machines. One of these units drilled and cored 650 ft. formations, where the setting up, drilling, tearing down, and moving required not more than 24 hours, and costs were obtained of 28 cents per foot.

In one Oklahoma field, 1,875 ft. wells were drilled with 6¼ in. bit for 60 cents per foot, every item of cost included, and economical drilling of first shallow and then deeper territories, warranted additional experimentation with more powerful units of practically the same construction with capacities for drilling 6¼ in. holes to from 4,000 to 5,000 ft.

Credit for the evolution of these machines belongs to several enterprising and far sighted engineers, drilling and production men, in many of the major oil companies, in cooperating with manufacturers in the designing and building of a rotary drilling machine, complete in itself with rotary table, swivel, kelly, hydraulic drilling feed, mechanically raised and lowered derrick, pipe racking board, crown block, draw works, mud pumps, auxiliary power unit with means of compounding with truck motor through power take-off for hoisting, with power drives, clutches and controls all unitized on a suitable truck.

No doubt this equipment will undergo improvement. Through its use in exploration new fields will be brought into existence where other methods are too costly. Many secondary recovery projects, formerly considered too deep for economic operation, will become practical and profitable under lowered drilling costs.

Many known and to be discovered areas of low per acre ultimate recovery will yield profits through this lower cost development. Some engineers are of the opinion that, in the not too distant future, new production methods of supplying reservoir pressure, initially through water or gas input wells, will make possible the flowing of wells to depletion and big holes of no extra value.

SUBSURFACE EQUIPMENT

All the power and auxiliary equipment operating above ground is of importance merely as a means of driving other tools and devices for reaching and recovering the oil that may lie far below. With the sinking of wells through all sorts of formations, in all parts of the world, to depths of as much as three miles, a long chapter, or even a book, might be written on recent developments in subsurface equipment, including improvements in casing, drill pipe, tool joints, bits and coring equipment as well as in methods of mud and cement handling.

With the increasing depths of wells, more and more importance has attached to the strengthening of drill pipe and particularly of tool joints where many of the failures in actual drilling have occurred.

(Continued on page 81)

BROADER FIELD For Use of Engine Electric Power

M. A. HYDE

Petroleum Industry Engineer; Westinghouse Electric & Mfg. Co.

IN THE application of power to rotary drilling equipment, one of the most striking recent developments has been the increasing use of Diesel and gas-electric drives. Whereas a short time ago it was considered that the field of usefulness of this type of equipment would be defined by locations where fuel or water suitable for boiler operation are not available at low cost, at the present time there are many equipments of this type in operation where fuel and water conditions are not difficult, and where they must, therefore, compete with steam rigs.

The fundamental reason for the use of electrical equipment in applying internal combustion engine power to the operation of rotary drilling equipment, lies in the fact that this type of engine is, in itself, ill suited to drilling rig operation because of its relative inflexibility and inability to start from standstill with a heavy load connected. Drilling service requires operation at widely varying speeds and torques, delivery at times of very heavy torques at very low speeds, and cyclic repetition of these conditions over considerable periods of time. In all operations smooth acceleration is desirable in order to minimize strain on the equipment. Adapting the characteristics of the internal combustion engine to these requirements is therefore a problem in power transmission.

In considering the relative merits of mechanical versus electrical transmission from the engine to the drilling machinery, the mechanical transmission has the advantage of lower first cost and higher theoretical efficiency, and the disadvantage of high maintenance and depreciation, particularly under severe operating conditions.

With mechanical transmission the hoisting load must be picked up through a slipping clutch from rest to minimum engine speed, and considerable skill, experience and care are required on the part of the driller to minimize mechanical shocks on the system and to avoid stalling the engine. For rapid operation, loads must be picked up quickly and heavy shocks and strains cannot be avoided; they can only be minimized by extreme care and skill, and repairs or replacements must be made frequently.

There are times when it is desired to operate the mud pumps at relatively high pressure and low delivery, which requires high torque at low speed on the mud pump drive. Also, it is desirable for protection of the hydraulic end of the pump to limit the maximum torque that will be applied in case of a sudden stoppage in the pump discharge. These are operating conditions to which mechanical drive does not lend itself.

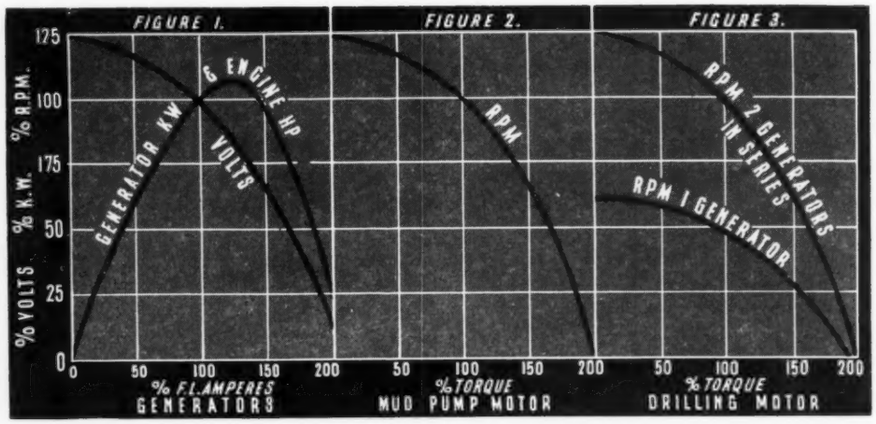


Figure 1—Volt-ampere and power ampere characteristics of specially compounded three field D.C. generators for variable voltage drilling service; Figure 2—Speed torque curve of mud pump motor operating with generator (Figure 1); Figure 3—Speed torque curve of drawworks motor when operating with single generator and with two generators in series.

In contrast to mechanical transmission, electric transmission using variable voltage control is inherently smooth, operating without imposing sudden speed changes and shock loads on the rig. Also, it is extremely flexible. With the load at standstill or low speed the torque may be varied from zero to full load, or to even twice full load. At full load torque the speed may be varied from zero to full load speed, while at light load the speed may be varied from zero to 125 percent. All this is done with the generating and engine equipment operating at constant speed regardless of the speed of the rotary table, mud pump or drawworks.

The generators are so designed as to limit definitely their input horsepower to a predetermined maximum within the engine capacity. This is important, because operation of the engines at no overload and constant speed reduces engine maintenance to the minimum. This limitation of imposed engine load is accomplished by using shunt wound motors with constant field excitation, fed by generators having field windings of special design to give a drooping voltage characteristic as the current increases. This characteristic is illustrated in Figure 1, and it will be noticed that when the generator current exceeds full load, the generator kilowatts and hence the engine horsepower reach a definite peak a few percent above full load after which further increase in current actually reduces the generator output and engine horsepower.

With mechanical transmission through a given ratio, the maximum torque applicable to the load is the same at starting as at full speed, and is substantially the equivalent of full load engine torque. Although the drawworks provides a selection of drum speed ratios for different hoisting conditions, there is not enough momentum to permit changing the speed ratio after the hoist is started, so the mechanical rig must operate with a fixed ratio between engine and hoist throughout any single hoisting operation. Consequently after the clutch is fully engaged the hoisting speed will not increase beyond the speed corresponding to maximum engine speed, regardless of how the load falls off. This means that as the hoisting load falls off, a corresponding percentage of the engine capacity is unused at top speed.

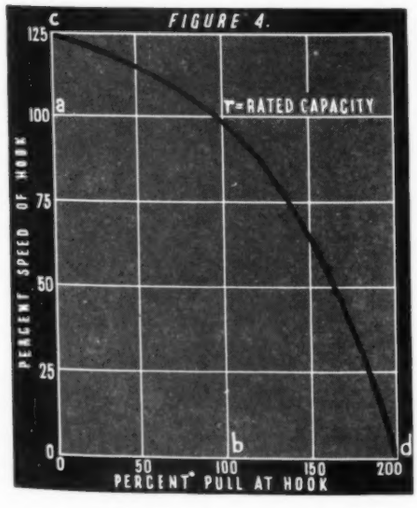
In contrast, the variable voltage rig has no fixed mechanical ratio between engine and load, but as seen from Figures 1, 2 and 3, permits the system to deliver increased torque with reduced speed up to a maximum of about two times full load torque at standstill. With this extra torque available,

a correspondingly greater breakaway pull can be delivered. Also after the load is started the extra torque available for acceleration means faster pickup. Then, if the load drops off, the speed increases up to a limiting speed which at no load reaches 125 percent of full load speed. All this makes for the most effective use of engine capacity throughout the entire operating range.

To put it another way, if two rigs, one using mechanical transmission and the other variable voltage electric, have the sustained capacity to hoist a given hook load at the same hook speed, then operating without change of drawworks ratio the electric rig can deliver about twice as much pull to the hook stalled as can the mechanical rig, and will raise the light hook about 25 percent faster. This is apparent from Figure 4 where r is the combination of hook load and hook speed representing the sustained hoisting capacity of both rigs. Area o-a-r-b is the operating range of the mechanical rig and o-c-r-d is the operating range of the variable voltage rig, all without change in drawworks ratio. Due to losses in the electrical system this electric rig would require about 15 percent more engine horsepower when operating at rated load; but from the engine capacity standpoint this is largely compensated by ability to apply engines at nearer actual peak capacity. This is true because electric transmission provides a definite limit to the load that the operators can impose on the engines.

The electrical rig has an outstanding advantage where it is necessary to handle heavy loads at sustained low speeds. One can really appreciate this when one sees an 11,000 ft. string of drill pipe coming out of the hole at a few inches a minute with the weight indicator held exactly at the first red mark on the scale, while the mud pump delivers 1,500 lbs. pressure with barely perceptible rotation.

Figure 4—Comparative operating range of mechanical rig (o-a-r-b) and variable voltage electric rig (o-c-r-d-).



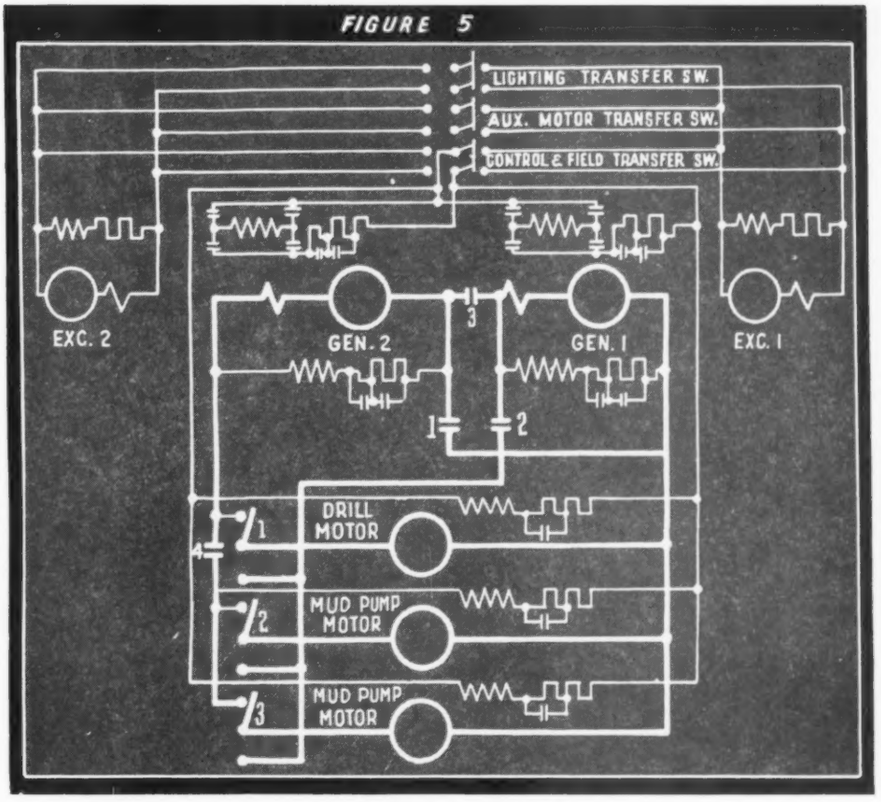


Figure 5—Typical schematic diagram for duplex rig, generators series-connected for hoisting.

Figure 5 shows typical connections for a two-engine, variable-voltage electric rig. The extreme flexibility of this equipment is well shown by the following operating combinations readily set up by different positions of the three main transfer switches:

NORMAL DRILLING—Generator 1 feeds Pump 1 or Pump 2; Generator 2 feeds drawworks motor.

DRILLING AND MIXING MUD—Generator 1 feeds Pump 1 pumping; Generator 2 feeds drawworks motor and Pump 2 mixing. Or Generator 1 feeds Pump 2 pumping and Generator 2 feeds drawworks motor and Pump 1 mixing.

EMERGENCY DRILLING—Generator 1 feeds drawworks motor; Generator 2 feeds Pump 1 or Pump 2.

NORMAL HOISTING—Generators 1 and 2 in series feed drawworks motor.

EMERGENCY HOISTING—Generator 1 or Generator 2 feeds drawworks motor giving normal pull but half speed.

HOISTING WITH MUD PRESSURE—Generator 1 feeds Pump 1 or Pump 2; Generator 2 feeds drawworks motor, giving normal pull but half speed.

COMPOUNDING PUMPS—Generator 1 feeds Pump 1; Generator 2 feeds Pump 2.

This control permits the driller to start, stop and reverse the drilling motor, and to start and stop the mud-pump motors. The generators may be connected to feed the motors independently, or they may be connected in series to feed the drilling motor for hoisting, all by operation of the master switches at the driller's location.

It will be noticed that in the foregoing discussion the two generators are connected in series for hoisting. Under normal operation equally satisfactory results are obtained by operating the two generators in parallel. However, the series connection for hoisting has one outstanding advantage over the parallel connection, in that in case of accidental outage of one generator, or simultaneous operation of the hoist and mud pump, the hoisting operation can be continued with only one generator, delivering the same load current but at half voltage. Under this condition the torque exerted by the drawworks motor is the same with one generator in service as with two generators since the current is identical in both cases, therefore the rig can exert the same maximum pull. However, the maximum motor speed can be only half that normally attained with the voltage of two generators in series. In other words, the rig overall can exert the same hoisting pull even though one generator is out of service, but is limited to half speed operation. On the

Courtesy Westinghouse Elec. & Mfg. Co.

Semi-electric Diesel-drilling rig using twin engines with variable voltage transmission to drawworks and V-belt drive to mud pump.

other hand, when the two generators are normally paralleled for hoisting and one is taken out of service, the current is halved with corresponding reduction in torque, so that the available hoisting pull of the overall rig is reduced to half its normal capacity. This may represent a serious handicap if the rig operations call for heavy pulling at the time.

The most popular combinations have been those comprising two engines and two D.C. generators of duplicate or nearly duplicate rating. With engines of low operating speed, the preferred method of driving the generators is by V-belts, which when adequately applied have given very satisfactory service. With higher speed engines, such as 900 r.p.m. and above, it is common to direct connect the generator to the engine shaft through clutch or coupling.

In these duplex units provision is often made for mechanically connecting one generator and its engine to the second unit. This is ordinarily accomplished by a separable coupling between the two generators when they are belt-driven and mounted on a single continuous bedplate, or by a cross connecting V-belt tie in the case of duplex units each mounted on a separate bedplate with its own engine. With either of these arrangements, during drilling operation when the generator supplying power to the rotary table is lightly loaded and the generator handling the mud pump is normally heavily loaded, excess capacity of the engine driving the rotary table can be transmitted to the mud pump generator thereby assisting the engine driving the latter unit.

A type of hook-up known as the semi-electric is being used extensively. This arrangement drives the mud pumps from the engines by mechanical transmission and the drawworks through a variable voltage electric system. The electrical system's smoothness, flexibility, high torque capacity and ease of control are thus available at the drawworks, where they are particularly important in hoisting.

A number of multi-unit rigs have been placed in service within the last year. They employ smaller consequently higher speed and lighter engines than the duplex units of same capacity. Figure 6 shows the engine room of a six unit equipment with 60 kw, 1,200 r.p.m. generators; as many as five may be operated in series for hoisting.

Courtesy Westinghouse Elec. & Mfg. Co.

Figure 6—Engine room of a six-unit rig showing 60 kw. r.p.m. generators coupled to 97 h.p. gas engines.

Typical drawworks motor, 300 h.p., 900 r.p.m., 400 volts for hoisting, 150 h.p., 450 r.p.m., 200 volts for rotary table drive. Power is received from two 150 kw. variable voltage generators in series when hoisting, and from one when drilling.

Courtesy Westinghouse Elec. & Mfg. Co.

A multiple generator rig of exceptional portability is one recently put into operation in West Texas, consisting of four 60 kw, 1,200 r.p.m. generators unit-mounted on the driving engines and all permanently assembled on a single trailer described on page 54.

It will be appreciated that the success of electrical transmission for this service involves not only the careful application and correct design of electrical units to match the engine capacity to the characteristics of the driven load, but also the practical working out of many mechanical details with particular attention to portability, ease of rigging up and taking down, and rugged construction to withstand the severe conditions imposed in operation and in transportation.

Near East's Deepest Well—
ZELOI No. 4

LAST year the Anglo-Iranian Oil Company Ltd. completed a drilling test which, up to that time, was the deepest well ever put down east of Suez. The well, known as Zeloi No. 4, was a wildcat located to the northwest of the Masjid-i-Sulaiman field in central Iran and was intended to explore the deep formation in that area. The ultimate depth of the well was 11,190 ft. While it did not develop production it did provide valuable geological information.

In accordance with the company's policy adopted on all test wells and in view of the possibility that high pressures requiring pressure control methods would be encountered, a cellar 22 ft. deep was constructed below the derrick floor. This cellar provided ample room for the connections which coupled each string of casing, and for the valves and blowout preventers which were fitted as a precaution.

An Oil Well Engineering combination rotary and percussion outfit with a 136 ft. derrick was employed for the drilling, the percussion gear being erected chiefly to supply a standby to the rotary drawworks in case of its failure and to enable inclinometers to be run on the sand line. The actual drilling of the well was carried out entirely by rotary tools.

Steam at 250 lbs. per square inch working pressure was used for the drawworks and slush pumps, while for the auxiliary services, including lighting, camp, mud mixing and workshop, petrol-driven electrical generators were installed.

The well commenced with a 14⅛ in. hole which was carried to 3,528 ft. At this depth a string of 11¾ in. O.D. inserted joint casing weighing 58.8 lbs. per foot was landed and cemented to surface. From this point a 10⅝ in. hole was drilled to 6,004 ft. and cased with 8¾ in. inserted joint casing weighing 38.5 lbs. per foot. This string was carried to 5,986 ft. and cemented to surface.

Drilling proceeded in a 7¾ in. hole to 6,670 ft. where an inclinometer reading showed a deviation of 8 deg. The hole was therefore plugged back with cement to 6,170 ft. and redrilled. At 9,552 ft. a string of 6¼ in. inserted joint casing, weighing 24 lbs. per foot and fitted with a left-hand threaded nipple at 3,556 ft. from the shoe, was run to 9,498 ft. and cemented up to this back-off nipple. The upper part was then pulled.

From 9,552 ft. the hole was reduced to 5⅜ in. and carried to 10,873 ft. When approaching this depth drilling difficulties due to mud ringing causing the bit to stick became more frequent and it was decided to run a liner to hold back cavings and to case off the porous mud ringing zones.

A liner 1,370 ft. long consisting of four inch inserted joint casing weighing 11.1 lbs. per foot was run on drill pipe to 10,676 ft. and cemented, the drill pipe being backed off at a left-hand joint connection between it and the top of the liner.

From 10,873 ft. drilling was continued with a 3⅞ in. bit to 10,961 ft. At this depth a core bit was run obtaining a core about seven inches long from which an indication of the dip of the formation was obtained. Normal drilling continued to 11,190 ft. when bailing tests were carried out. Although the results of these tests proved to be only water the information obtained from this well, in proving the existence of the Asmari limestone, provided very valuable information on the geological conditions obtaining in this area.

No fishing jobs arose during the drilling of this well.

First 10,000 ft. well drilled East of Suez —Zeloi No. 4.

© Anglo-Iranian Oil Co., Ltd.

Although a dry hole, this 11,190 ft. well provided valuable geological information.

The formations drilled can be roughly divided into four groups, as follows:

0 ft. to 900 ft. Gypsum, Anhydrites, Shales and Marls.

900 ft. to 6,500 ft. Anhydrites, Salt, Shales and Marls.

6,500 ft. to 10,700 ft. Chiefly Anhydrites and Salt.

10,700 ft. to 11,190 ft. Limestone.

In view of the alternating beds of hard and soft formation which were encountered it was found that rock bits gave the highest all-round drilling speeds. These bits were therefore used for approximately 90 percent of the drilling, the balance being drilled by fish-tail bits.

The well was spudded in on May 17, 1936, and reached its final depth of 11,190 ft. on April 8, 1937, a total of 327 working days. Of this total, 189 days were occupied by actual drilling, giving an average footage of 59.2 ft. per drilling day of 24 hours, and an average progress rate of 34.2 ft. per day over the total working period.

OFF-SHORE Drilling in South Sea Surf

Figure 2—Well No. 78 drilling at dead low tide off the coast of Brunei.

WITH the attention which is now being giving to obtaining oil production from areas below sea level, it is interesting to consider some particulars of the methods successfully employed by the British Malayan Petroleum Company, Ltd., a subsidiary of the Shell Group, operating in the State of Brunei in British North Borneo.

Successful drilling had been carried on for some years along the coast and production of heavy oil obtained from a depth of under 2,000 ft. and a light oil from about 5,000 ft.

It was apparent from torsion balance surveys made when the field was discovered, and by core drilling that a part of the structure lay in the sea.

The coast line of Brunei faces in that part nearly due North, and is exposed to strong winds and rough seas during six months of the year, so that a very substantial platform has to be provided when underwater drilling is to be done.

The first such well was drilled in 1934 to reach the shallow heavy oil level and was successfully completed at a depth of 1,780 ft. The depth of water at high tide was 15 ft. at a distance of 700 ft. from the shore. The method of construction of the platform was as follows:

The foundations were built with precast reinforced concrete piles. The piles were cast on the shore and were 56 ft. long and of octagonal section, the maximum cross section being 14 in. and weighed approximately 4½ tons. These were transported by Decawville line to the well site and lifted by a 10 ton hand crane and driven with a three ton monkey assisted by water jet. The average penetration of the piles

was 30 ft. Five piles were driven for each bent for the four corners of the derrick, four piles in the centre to take the load of the rotary machine, one pile in the centre between each corner bent of piles and four for the engine foundation. A reinforced block was cast on the top of each nest of piles and a reinforced concrete beam from each forming a square. On the concrete foundation an R. S. J. structure was erected to take the derrick base. The main members of this steel structure were made of two 12 in. by 5 in. I-beams rivetted together. The derrick was connected to the shore by a board walk made of welded junk 6 in. pipe. The foundation stood up

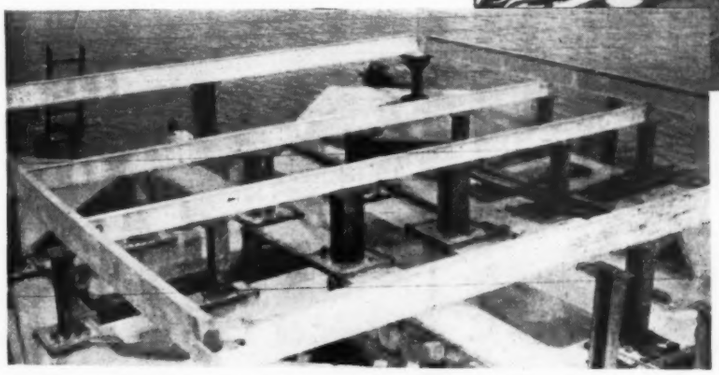
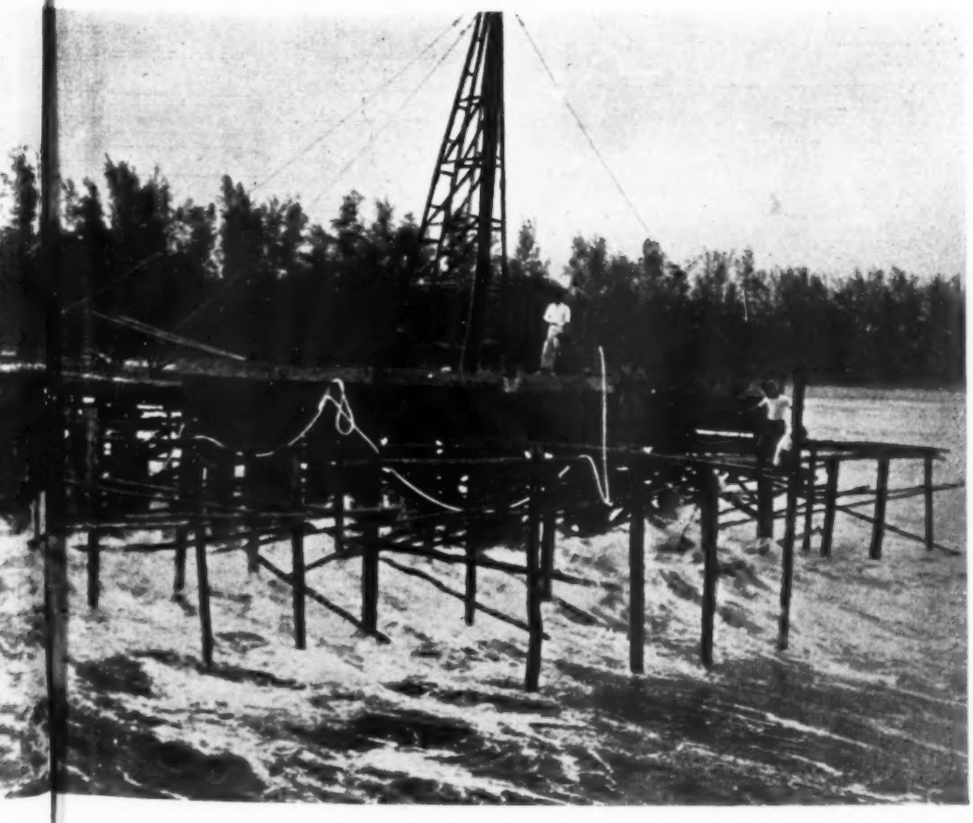


Figure 1—Roughness of the surf presents difficulties in construction of the platform for well No. 41.



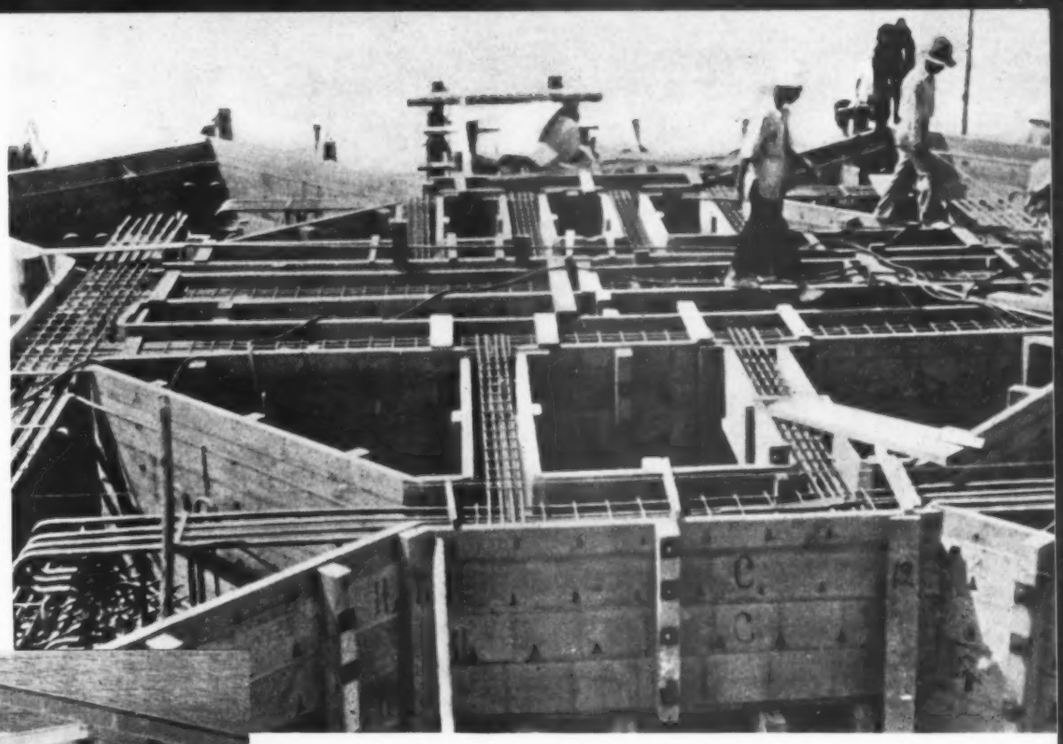


Figure 3 (left)—Concrete top and steel superstructure in place with derrick base beams above, well No. 78. Figure 4 (above)—Strengthening and reinforcing prior to running concrete, well No. 78.

to the strain of drilling and heavy weather and has shown no sign of subsidence or breakage.

Figure 1, shows platform under construction and Figure 2, derrick erected.

A second well was drilled at a distance of 900 ft. from the shore. This was projected for a depth of 5,000 ft. to 6,000 ft. and much stronger foundations were consequently required to allow for the weight to be carried if say 6,000 ft. of right- and left-hand drill pipe was stacked in the derrick at the same time.

In view of the limited expected period of favorable weather conditions a temporary timber board walk was constructed in four weeks, commencing May 9, 1936, to allow access to the foundations and so enable the work on foundations and permanent boardwalk to proceed simultaneously.

The derrick foundation was constructed in eight in. diameter disused drill pipe and nine in. diameter scrap casing, with reinforced concrete caps, and beams.

In all 66 piles averaging 80 ft. long each, were jetted and driven to position.

Despite periods of very heavy seas good progress was made and the well was spudded in on October 31, 1936.

The well was completed in the light oil series at 5,790 ft. (plugged back from 6,065 ft.) on July 15, 1937.

Figures 3 and 4 show construction in progress.

Further wells have been drilled with the same general design of foundations which allow of directional drilling so that from 3 to 4 wells can be completed from one foundation, thus dividing the heavy cost of this work among several wells.

SUSTAINED ACTION ACID May Solve Mid-Continent Problem

John G. Staudt and W. W. Love

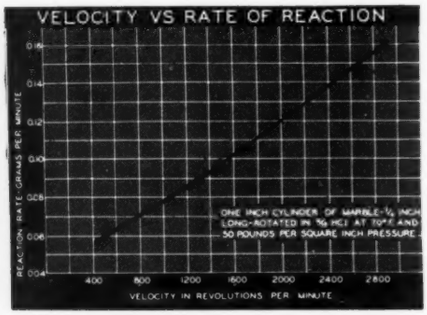
Dowell Incorporated, Tulsa, Oklahoma

A DEFINITE improvement in acidizing results can be expected by the use of a new type of acid now developed and tried out in the field. This new acid has a slower rate of reaction with the formation and consequently the action on the formation is sustained for a longer period of time. This permits further penetration of the acid into the formation before the acid completely spends itself. This penetration can be obtained in no other known way. The use of this new acid is especially beneficial in retreatments and in the treatment of quickly acid soluble, permeable formations.

Back in the early days when acidizing was confined to fields in Michigan, it was common practice to acidize new wells, allow them to produce for a number of months until the production declined and then to go back and re-acidize them. Usually a larger quantity of oil was used on the retreatment to push the acid on into new territory and a larger amount of acid was used in each retreatment than in prior treatments. As many as seven retreatments have been made to one well with increases in production resulting from each one.

When acidizing became established in Kansas, Oklahoma, Texas and other areas in the Mid-Continent, the acidizing practices already established and proven in Michigan were transferred to these new areas and used without much question, due to their prior success. However, it was not long until it became evident that the Michigan retreatment technique was not giving nearly as satisfactory results in some areas in the Mid-Continent as it had in Michigan. The wells in some Mid-Continent areas responded satisfactorily to one retreatment and a few of them to two, but in general the results were not as satisfactory as in Michigan.

Figure 1

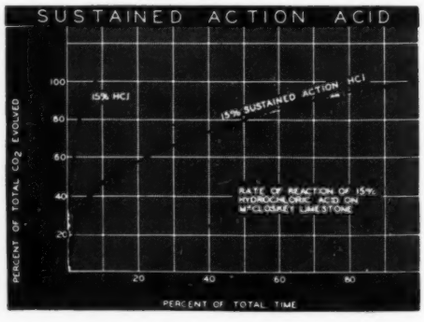


The mediocre retreatment results in the new areas led to an investigation which disclosed that the type of porosity in the producing formations in Kansas, Oklahoma, Texas and other oil producing states differed considerably from that in the Dundee formation of Michigan. The pores in general, were larger and therefore larger quantities of oil used to force the acid back into the formation were not effective because of by-passing. Therefore on retreatments, it was very probable the acid never got very far away from the hole even though tremendous quantities of flushing oil were used.

Numerous methods were tried to overcome this difficulty, the most successful of which was the use of larger quantities of acid on retreatments than were used on the first treatment. Acid treatments of 15,000 to 30,000 gallons, while never the rule, at least were not unusual. The excess quantity of acid over the amount used in the first treatment caused some penetration into an area not previously acidized.

The benefit from larger quantities of acid used in retreatments was instrumental in bringing into general practice the use of large quantities for initial treatments. The average gallonage throughout the United States in all types of wells is now somewhat over 2,500 gallons per well as against an original average of less than 1,000 gallons.

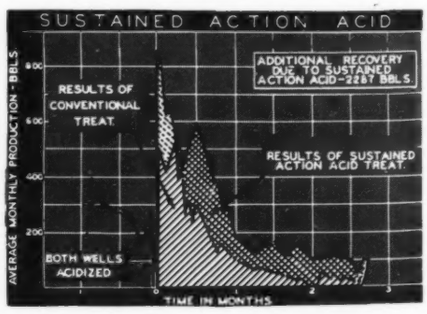
Figure 2



In a large proportion of fields, the increase in amount of acid used brought correspondingly larger increases in production but in a number of fields results obtained were not as good as had been expected. In these fields the formations were free from impurities, easily soluble, had adequate porosity, permeability and saturation and normal bottom-hole pressures. Yet increases in production resulting from acidizing were only fair.

Extensive laboratory and field research isolated the probable reason for this disappointing response. It developed that the rate of reaction was extremely rapid between ordinary inhibited acid and these Mid-Continent limestones. Some samples reacted so rapidly it was concluded that spent acid was being forced back into the formation in large gallonage treatments, most of the acid being spent close to the well bore. The section of the formation immediately around the well was being treated much too heavily and the permeability was being increased more than was economically needed. A portion of the acid that was assigned in the well operator's mind to treating a portion of the formation away from the well really was not doing what it was supposed to do. Large gallonage was therefore only a waste of money.

Figure 3



Experimentation was immediately started to find some means of getting deeper penetration into the formation before the acid was spent. There were several attacks to this problem. In the first place, it was known that the speed of reaction between hydrochloric acid and limestone decreased as the temperature decreased and therefore the use of cold acid was one of the first steps to solve the problem. Ice was put into the acid tanks so the acid would be as cool as possible before entering the well. However, it was found the acid increased in temperature materially between the treating station and the well. Also it was thought probable the acid temperature had increased in going down into the well to the temperature prevailing at the bottom of the hole. Therefore, this type of treatment has been abandoned simply because it cannot be made to work.

The next approach to a solution of the problem was the more rapid introduction of the acid into the well. Large volume, high pressure pumps were designed and some improvement was noted in the results as soon as they were put into use. Pumps capable of 125 bbl. of acid per hour were made standard equipment as against pumps capable of only 30 bbl. per hour. These same pumps are capable of up to 3,000 lbs. pressure as against the 1000 or 1200 lbs. that was thought satisfactory in the early days. This increase in pressure was needed as the greater rate of flow naturally increased the pressure differential required to force acid into the formation.

Since some improvement was noted with the use of a larger pump, the idea was carried somewhat further and two, three and even four pumps have been used to

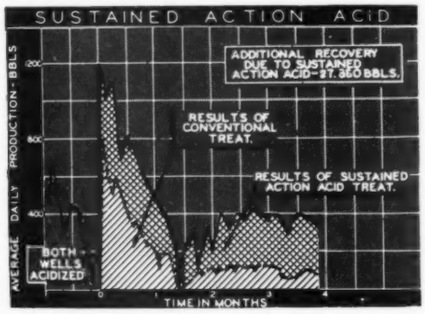

SUSTAINED ACTION ACID
ADDITIONAL RECOVERY DUE TO SUSTAINED ACTION ACID-37,360 BBLS.
RESULTS OF CONVENTIONAL TREAT.
RESULTS OF SUSTAINED ACTION ACID TREAT.
BOTH WELLS ACIDIZED
AVERAGE DAILY PRODUCTION - BBLS.
TIME IN MONTHS

Figure 4

speed up the introduction of the acid. Acid and oil are now being introduced into a well as fast as possible without raising the pressure to such an amount that damage may be done to the well equipment.

All of these pumps and extra equipment looked very nice at a well but they did not produce materially improved results. It was thought that if acid was put in four times as fast, it would go four times as far, but this is not at all true simply because the rate of reaction between limestone and hydrochloric acid increases very rapidly as the velocity of the acid moving through it increases.

It is only natural to expect that increased velocity will increase the rate of reaction. When testing a small sample of rock in a test tube of acid, the reaction is hastened if the test tube is shaken. A laboratory test was made to get data on this particular point and the results are shown in Figure 1.

This shows there is a definite limit on the rate of introduction beyond which nothing is gained because it will be found the increased rate will neutralize almost entirely the increased velocity of flow.

A third method of attempting to get deeper penetration was the use of a more dilute hydrochloric acid solution. This uncovered an extremely interesting and debatable point but it soon became obvious that decreasing the concentration of the acid also decreased the effectiveness of the acid. Concentrations were used down to the point where the acid could not possibly do any good even if it did penetrate a great distance. None of these tests showed outstanding results and so this method of approach also has been discarded along

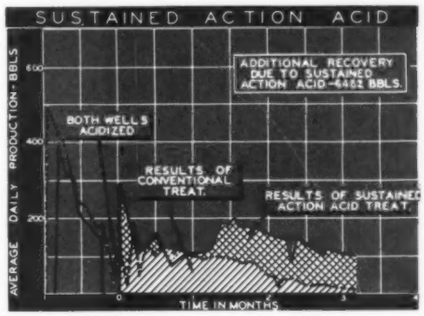

SUSTAINED ACTION ACID
ADDITIONAL RECOVERY DUE TO SUSTAINED ACTION ACID-6482 BBLS.
BOTH WELLS ACIDIZED
RESULTS OF CONVENTIONAL TREAT.
RESULTS OF SUSTAINED ACTION ACID TREAT.
AVERAGE DAILY PRODUCTION - BBLS.
TIME IN MONTHS

Figure 5

with the idea of getting more penetration by using more pumping equipment.

Laboratory work on the problem finally centered around an entirely new viewpoint. Attempts were made to find a chemical or chemicals which would be either a slower acting solvent than hydrochloric acid or would be an addition agent to be mixed with the acid to produce a sustained action on limestone.

In the search for such a retarding or sustaining solvent, the investigation was limited by having only two factors which could be modified. The solvent solution itself might be changed, or in a manner of speaking, the formation might be changed. The possibilities of changing each of these factors were thoroughly investigated over a long period of time.

The various types of substances which sustain the reaction between the solvent and limestone may be divided into two classes.

In the first class is hydrochloric acid to which is added certain compounds which reduce its rate of reaction without causing any precipitation. Also in this class are the slightly ionized, weak acids which dissolve limestone similarly to hydrochloric acid only more slowly. In the second class is any acid containing a small amount of an agent which precipitates as the reaction proceeds. The precipitate partially covers the limestone and prevents the acid from reacting at its regular rate.

Naturally, it was necessary to limit the investigations to those materials forming a precipitate which would not plug up the pores and thus reduce the production from the well. One of the basic principals in all investigations of acid treatment is that possible damage to a well must be reduced to a minimum.

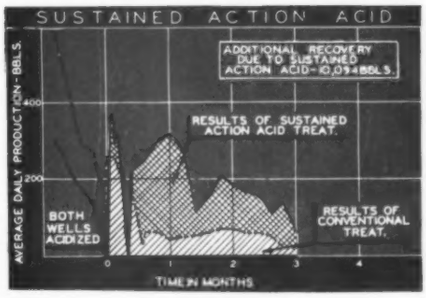

SUSTAINED ACTION ACID
ADDITIONAL RECOVERY DUE TO SUSTAINED ACTION ACID-10,094 BBLS.
RESULTS OF SUSTAINED ACTION ACID TREAT.
BOTH WELLS ACIDIZED
RESULTS OF CONVENTIONAL TREAT.
AVERAGE DAILY PRODUCTION - BBLS.
TIME IN MONTHS

Figure 6

It was found that some agents will form a slight precipitate immediately next to the limestone due to the fact the reaction between acid in a pore and the formation itself must of necessity take place at the interface of the acid and the limestone, or on the walls of the pores. Therefore, it was not necessary to form a precipitate which would completely plug up the pore but it was really only necessary to form a precipitate that would interfere with the reaction at the interface. Since the interfacial layer can be considered only a molecule or so thick, it is obvious the amount of precipitate necessary is really so small it need cause no plugging in the pores themselves. Even though pores are small they are hardly of molecular size, so no plugging trouble need be experienced if the proper reagents are used.

The laboratory investigation also showed there were some reagents which might be added to acid which would sustain the rate of reaction without causing any precipitation. The action of these materials is not known in detail. But it is interesting to note that the effect of some of these retarding agents is not particularly noticeable at atmospheric pressure and becomes very apparent as soon as the pressure is increased. This may be explained by the assumption that during the reaction under pressure, certain compounds are formed which are not stable at atomspheric pressures. As long as the acid remains under pressure, the new compounds will be present and the retarding effect will be noticed.

These additive materials act on the limestone very similarly to the way in

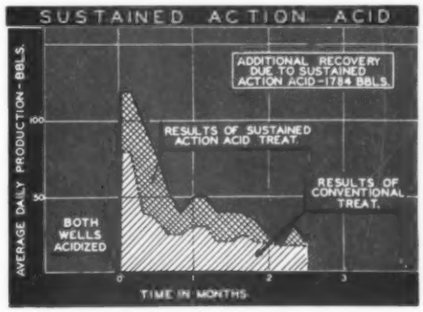
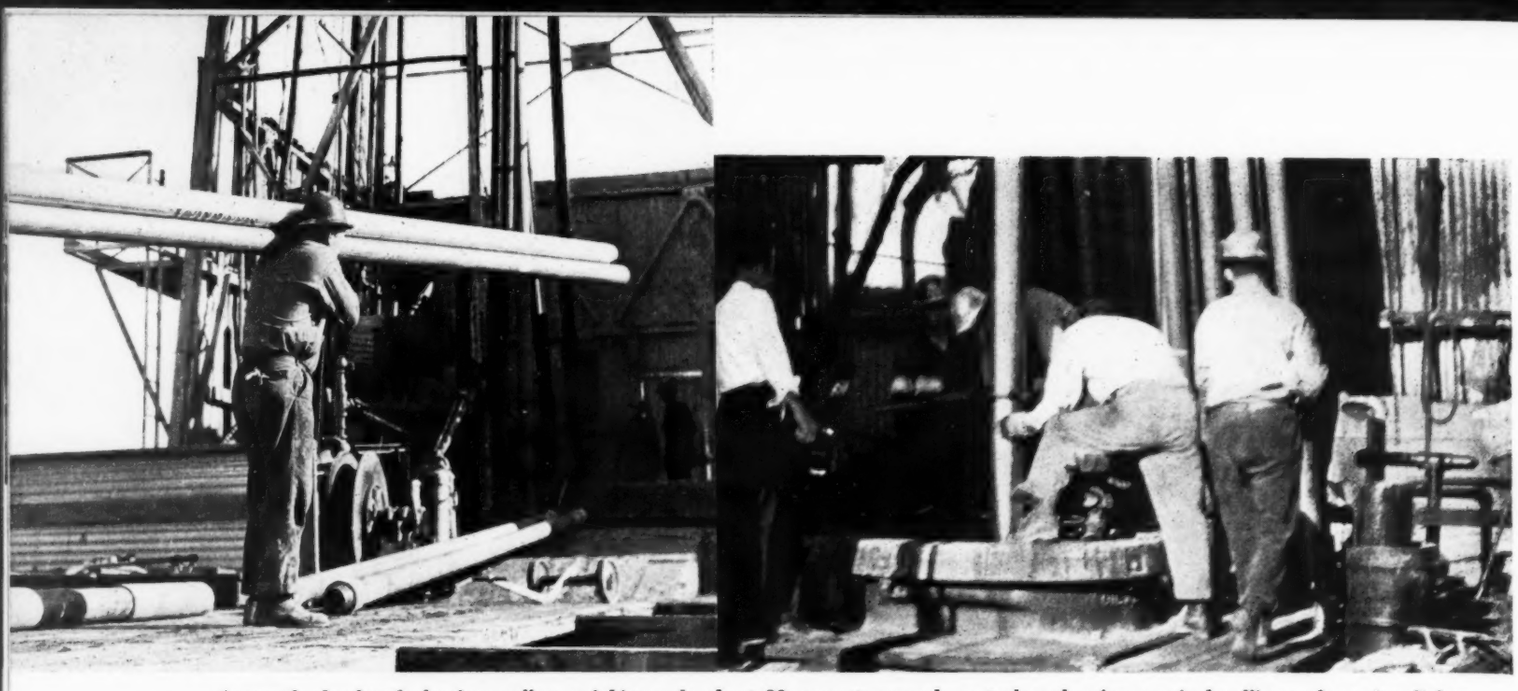

SUSTAINED ACTION ACID
ADDITIONAL RECOVERY DUE TO SUSTAINED ACTION ACID-1784 BBLS.
RESULTS OF SUSTAINED ACTION ACID TREAT.
RESULTS OF CONVENTIONAL TREAT.
BOTH WELLS ACIDIZED
AVERAGE DAILY PRODUCTION - BBLS.
TIME IN MONTHS

Figure 7



A recently developed aluminum alloy, weighing only about 30 percent as much as steel, makes for ease in handling and requires lighter equipment, as in the case pictured above where Securaloy liners are being used on a California well.

which inhibitor acts on a metal surface. An inhibitor deposits a thin film, about one molecule thick, on the surface of the metal and this molecular layer acts as an impermeable mechanical barrier to the acid. This film is deposited only on metal and, in spite of some ill advised assertions to the contrary, does not affect the action of the acid on limestone. It is possible the molecular film action will explain the action of the retarding agent. The retarding agent will produce a molecular film of this nature on the grain of limestone.

Due to the irregular surface on the interior of limestone pores, the molecular film does not seem to be continuous, but it is continuous enough to prevent a very considerable portion of the limestone from coming into contact with the acid and rate of reaction is definitely retarded.

Figure 2 shows the magnitude of the sustaining effect on a very easily soluble limestone. The rate of reaction is retarded more than 90 percent. These tests were made using materials which show retarding action at atmospheric pressure. Certain other agents do not show any apparent sustaining action at atmospheric pressure but require the test to be made under pressure to show the difference in rate.

The need for sustained action acid has long been recognized. The evidence shows such an acid will be less adapted to the treatment of wells producing from relatively open and quickly acid soluble formations. If the reservoir is such a type that appreciably greater penetration can be obtained by using a slow acting acid, then retarded acid should give better results than regular acid.

There are some formations which already act at a very slow rate and it remains to be seen whether the use of retarded acid will produce better penetration than that already being obtained, or if obtained, whether this better penetration really is necessary in the treatment of such a formation.

In tight formations, where the rate of fluid injection is very slow due to the tremendous friction involved in passing fluid through the formation, it is probable that little could be gained by the use of sustained action acid, particularly on the first treatment or first stage on the well. However, after the formation has been opened up and the permeability is adequate, then the use of retarded acid may very definitely be indicated.

Extensive application of the new sustained action principle has been made in a limited number of areas and the results have been extremely gratifying. Figures 3, 4, 5, 6, and 7 show the results of retarded acid in the Illinois area.

Here production is found in the McCloskey limestone which is a fast acting oolitic limestone easily opened up by the action of inhibited acid. Results in this area have been above the average of conventional acid treatments and it has been possible to prolong the flowing life of many wells by better utilization of reservoir energy, and to make commercial producers out of edge wells that were practically dry holes.

This field was chosen for first experiments using sustained action acid because it filled all the requirements that it was thought a formation should possess to respond favorably to this new type of acid.

It was found in Illinois that, although the initial response to acidizing was appreciable, the rate of decline was outstandingly decreased.

In each of Figures 3, 4, 5, 6, and 7 the production curve on two offset or nearby wells is plotted. A zero date is shown which is the date on which both wells were treated and time is computed in months before and after acid treatment without regard to the actual day of the month involved. Since all these wells are comparatively the same age, this method of plotting introduces no appreciable error. Production of the wells before and after treatment is shown and in every case it will be noted that the use of sustained action acid has produced a very definite increase in the oil produced from the wells.

Immediately after treatment there was little or no difference noted in the production of wells treated with sustained action acid. Apparently the new acid had done no extra good. But as production data continued to come in week after week, it was noted that the decline was definitely less and when this same situation occurred in every test made it was obvious the mathematical chances of these differences being merely a coincidence were remote.

It would be expected normally that, if sustained action acid were successful in reaching far back into the formation and were more effective in increasing the permeability, the initial production immediately after treatment would be greater than when treated with conventional acid. However, it appears that the Illinois wells shown in the figures produced as much oil as the reservoir energy could move into the well. Therefore the production immediately after treatment was no greater than usual due to the fact that production was a measure of reservoir energy at that time rather than of oil available. As soon as the amount of oil readily available to the well had become somewhat reduced, the effect of deeper penetration became apparent.

(Continued from page 71)

Metallurgists have studied the problem of providing increased structural strength while equipment engineers have sought to accomplish a similar end by improvements in design. One steel manufacturer has just put out a new type of tool joint in which the distinctive feature is an increase in the length of the upsets on the pin and box ends which eliminates the necessity of tonging on the body of the pipe with the possibility of damage from this cause.

TURBO DRILL

April, 1938, witnessed the completion of an oil well drilled by a new method. The well is Emery 65 of the Standard Oil Company of California. It was drilled by A. O. Smith Corporation which has been co-operating with Standard in development of the drilling device known as the Scharpenberg Turbo Drill, so named after its inventor, C. S. Scharpenberg of Standard.

The turbo drill is a unit which applies the power directly to the bit where the work is being done, rather than at one end of a long and relatively fragile torque tube at the other end of which is the bit.

As the name implies, the turbo drill is driven by a turbine or hydraulic motor, deriving its power from the energy imparted to the drilling fluid by the pumps. The drilling bit is screwed directly into the lower end of the drill and is rotated thereby.

The unit used in drilling Emery 65 is nine inches in diameter and 25 ft. long. It develops 75 h.p. when running at full load. Its surprising feature is that it rotates bits as large as 18 in. diameter at a steady speed of 600 r.p.m., three times faster than bits of this size run by ordinary rotary.

Surprisingly enough, certain types of bits stand up just as well at these high speeds as at rotary speeds and hole is made at a rate approximately proportional to the speed. An 18 in. bit turning at 600 r.p.m. has a peripheral speed of over 2,800 ft. per min.

Ordinary rotary equipment is used with the turbo drill but not in the conventional manner. The hoisting engine is idle and there is no sound heard in the rig but the exhaust of the pumps and the hum of the mud screens. The only evidence that hole is being made is steady disappearance of the kelly and the unwrapping of the cable from the drum.

Because of the high speed, the weight carried on the bit is usually less than one half the weight for rotary and a remarkably straight and clean hole is the result.

In Emery 65, 13⅜ in. casing was cemented at 3,150 ft. in 18 in. hole, and 8⅝ in. casing was cemented at 3,900 ft. in 12½ in. hole. Hughes rock bits were used exclusively and the entire 4,000 ft. of hole was made and cased in less than a month. Additional and deeper wells are planned.

Developments in casing have been mainly in the direction of providing higher compression and tensional yield strength and improving couplings and joints. Much attention has been devoted to the perfection of full welded casing and some remarkable records have been made recently in running extreme lengths of this type of casing in rapid time.

One advance that has greatly simplified the work of the deep well drillers and increased recoveries is the practice of gun perforating the casing at various depths in tests to determine production from various horizons. This has proved particularly valuable in sections like the Gulf Coast where several sands of greater or less productivity exist at different depths.

Seventy percent of the deep wells gun perforated in the Gulf Coast are new wells. In these wells drilling is continued through the deepest known productive measure and a single string of casing cemented to the bottom of the well, sufficient cement being placed behind this casing to seal off all of those known productive sands.

The lowest sand is then gun perforated and production continued until the sand has been depleted or until water encroachment makes further production unecomic. This horizon is then abandoned, plugs placed and the next higher sand measure perforated.

Engineering progress has been made in this type of completion through studies of sand characteristics, formation pressures, flow velocity, and drainage openings, which has resulted in greatly simplified production problems. Definite location of the productive sands has simplified the later gun perforating problem.

This type of completion has provided a close control of the gas-oil ratios, and improved cementing technique has made possible reconditioning where either excessive gas-oil ratios have been obtained or where water has been encountered in the lower portions of the sand body.

The economic advantages of this type of completion can readily be appreciated when it is realized that one drilling operation and one string of casing makes possible production from several successive zones. Another interesting consideration is the large increase in reserves which has resulted in the Gulf Coast area from the intentional casing-off of productive sands, estimated at over 1,000,000,000 bbl.

Intense research and experimentation is under way with regard to the well completion method known as Gravel Pack. This consists of enlarging the hole adjacent to the producing zones to the largest possible diameter by means of rotary underreamers or wall scrapers. Screen pipe of predetermined gauge is inserted and then gravel of proper grain sizes pumped into the hole to fill the annular space between perforated pipe and the wall of the enlarged hole. In theory a filter bed is thus created of permeability approaching ideal producing conditions.

It is impossible to compute with any degree of accuracy the additions to available oil reserves due to recent advances in drilling technique and equipment but the quantity must be reckoned in thousands of millions of barrels. The ingenuity of inventors and manufacturers has not been exhausted. As operators encounter new problems or seek to penetrate greater depths equipment engineers will be ready to provide the means of accomplishment.

Acknowledgment is made of information and valuable assistance received in the preparation of the preceding article from Continental Supply Co., Emsco Derrick & Equipment Co., Continental Emsco Co., Petroleum Machinery Co., Farrar and Trefts Boiler Co., Gardner-Denver Co., Portable Rig Co., Jones & Laughlin, A. O. Smith Corporation, Franks Manufacturing Corporation, Hughes Tool Co., Security Engineering Co., Lane-Wells Co. and many others.

(Continued from page 39)

States from Brazil were valued at $119,537,000, leaving a balance of $51,000,000 in Brazil's favor.

Whether the policy now adopted will be of practical advantage to Brazil remains to be determined. It will involve, of course, a serious loss of revenue to the government which may amount to $10,000,000 or more yearly. The argument which seems to have been most effective in bringing about the adoption of the present policy seems to have been that of greater security in time of war, but the experience of other countries indicates that from the viewpoint of national security a nation which can draw finished products in such quantities as may be needed from any part of the world is in a stronger position than one which must depend on imports of crude alone and which has large refining plants that are outstanding marks for attack.

In quality of products dispensed and in service to consumers, the system of free competition has shown itself far superior to an officially maintained monopoly. In the case of Brazil, however, the law appears to leave considerable latitude to the Council and it seems probable that changes in the existing organization of the petroleum trade will be introduced only gradually. The system finally adopted may prove to be less radical than outsiders have assumed from publication of the decree.

Foreign Oil Legion

Dr. A. E. Dunstan.

DR. A. E. DUNSTAN, D.Sc., F.I.C., M.Inst.P.T., chief chemist of Anglo-Iranian Oil Company Ltd., has been awarded the Redwood Medal of the Institution of Petroleum Technologists in recognition of his distinguished services to the science and technology of petroleum. The medal, which is awarded irrespective of nationality or membership in the I.P.T., has been awarded on three occasions: in 1932 to DR. L. EDELEANU; in 1934 to DR. DAVID WHITE; and in 1936 to HARRY RICARDO.

Presentation was made at a meeting of the I.P.T. April 12th, by the president of the Institution, LT.-COL. S. J. M. AULD, O.B.E., M.C., D.Sc., of Vacuum Oil Company Ltd.

Dr. Dunstan is well-known and admired by his contemporaries on both sides of the Atlantic. Born in 1878, at Sheffield, England, he entered the Royal College of Science in 1899. Later, while studying at University College, he collaborated with Trouton on investigations into the correlation of physical properties and chemical constitution. He had already published work on viscosity-concentration curves of mixtures. This work was continued and formed the subject of his thesis in 1910 for the degree of D.Sc. In the meantime he had collaboration on problems of viscosity with Thole, Wilson, Hunt, Stubbs and others.

Dr. Dunstan was head of the chemical department of East Ham Technical College from 1905 to 1915. In the latter year he joined Anglo-Persian (now Anglo-Iranian) Oil Company Ltd., from which time dates the important series of researches on the chemistry and refining of petroleum with which his name is associated. In 1916 he presented his first important paper dealing specifically with petroleum—"Pyrogenesis of Hydrocarbons," by Dunstan, Lomax and Thole, dealing with the evolution of cracking and the principles underlying it. At the time the three were engaged in manufacture of toluene (basis for TNT) on a large scale for purposes of national defense.

In 1917, when desulphurization was still in the empirical stage, Dr. Dunstan discovered that the key to successful commercial desulphurization by hypochlorites was the quantity of free alkali present. Following his work on hypochlorite treatment he collaborated with Thole in investigating solvent refining methods, and in particular the liquid SO_2 treatment associated with the name of Edeleanu. Described first by Edeleanu in 1907, this has been adapted by Dunstan during the war for toluol manufacture. Its extension to refining of light petroleum distillates was the subject of researches from 1920 to 1923, after which he conducted a series of investigations into the nature of the components of lubricating oils—a field still widely engaging the attention of physicists and chemists. Altogether he has contributed over a hundred papers to scientific societies and periodicals.

Besides being chief chemist of Anglo-Iranian, Dr. Dunstan is also a director of National Oil Refineries Ltd. He was president of the I.P.T. from 1929 to 1931 and has been a member of council since 1919; he has also been honorary editor of the I.P.T.'s publications from 1920. A former member of His Majesty's Fuel Research Board and government delegate to the Second World Petroleum Congress, Dr. Dunstan is chairman of the petroleum committee of the Imperial Institute Mineral Resources Division. Among his numerous other activities of the like, Dr. Dunstan is honorary chairman of the committee on petroleum products of the American Society for Testing Materials.

A Polish government-sponsored oil commission arrived in New York on the liner Batory, April 16th, for an extended visit to the United States. From left to right: Zozislaw Ziolkowski, Mrs. Ziolkowski, Professor Stanislaw Pilat, Zozislaw Tomasic, Mrs. Pilat, Professor Thadeusz Blauth Royszard Monsior and Zozislaw Wilk. While in New York the group has been staying at the Hotel Gotham. American oilfield and refinery practices are being studied.

© International News Photo

C. H. MULLINGER, assistant treasurer of International Petroleum Company, passed through New York en route from Toronto, Canada, to Talara, Peru, during the early part of April. He sailed on the SANTA LUCIA for Lima, April 9th.

CORNELIUS F. BURK, of International Petroleum Company, passed through New York late in April en route from Sarnia, Ontario, to Talara, Peru. He sailed on the liner SANTA CLARA April 30th.

FRANCOIS LIMAY was recently awarded her Canadian master's ticket with distinction, and is now captain of the St. Lawrence river tanker ADELPHIE. Miss Limay is believed to be the only woman skipper of a bulk-oil carrier.

C. A. LAMBERT, director, MARC FERRAUD, general manager in charge of sales and distribution, and R. SCHLUMBERGER, assistant general manager, all of Pechelbronn Societe Anonyme d'Exploitations Minieres, arrived in New York on board the liner NORMANDIE May 2nd. They will be making their headquarters at the Hotel Waldorf Astoria while in the East, and during the 10 weeks they are in the United States will study American methods of production, refining and marketing. Principle cities on their itinerary when they arrived were: Tulsa (where they will visit the Oil Show), Houston, and New Orleans. Pechelbronn S.A. is France's chief oil producer, with about 600 pumpers at Bas-Rhin (Pechelbronn), two refineries, about 100 mi. of pipelines, and several marketing subsidiaries.

Courtesy Union Oil Bulletin

A party was held recently at Kobe, Japan, in honor of W. W. Baer—special representative of Union Oil Company of California—on the eve of his departure for the homeland on a well-earned vacation. The lady on the extreme left is Mrs. Baer, while Mr. Baer is third from the left.

LT.-COL. J. H. M. GREENLY, C.B.E., chairman of Babcock & Wilcox Ltd. and member of the advisory council to the Committee of the Privy Council for Scientific and Industrial Research, has been appointed president of the Institute of Fuel.

French oil company executives shortly after disembarking from the Normandie—left to right: C. A. Lambert, R. Schlumberger and Marc Ferraud (Pechelbronn S.A.); C. H. Longshore (Longshore Petroleum Company); J. P. Dankell (National Supply); and M. F. De Muller (export representative of Chrysler Corp.).

© World Petroleum

BRUNO WINKLER, geophysical research engineer of Standard Oil Company of New Jersey, sailed from New York April 9th en route from Houston to Palembang, Sumatra. He was accompanied by his family, including his eight week-old son. When Bruno Jr. arrives at Palembang he will have spent nine of his 14 weeks of life in travel.

W. G. GREEN, president of Engineering Laboratories Inc. and vice-president of Seismograph Service Company, Tulsa, is in Argentina in connection with exploratory operations of Yacimientos Petroliferos Fiscales—government controlled oil company. He will visit Venezuela and Trinidad before returning to the United States. Increased activity in the search for petroleum in all parts of the world has added greatly to the international operations of geophysicists since the beginning of the year. T. A. MANHART, assistant vice-president of the company, has just returned from the Near East, while a crew of five is now on its way to Netherland India, in the Far East.

W. G. Green.

WORLD OIL PRODUCTION—Official Figures

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified—Table revised monthly

(Figures in U.S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries)

	April 1937	May 1937	June 1937	July 1937	August 1937	September 1937	October 1937	November 1937	December 1937	January 1938	February 1938	Preliminary Figures March 1938
United States	104,979,000	110,911,000	105,812,000	110,721,000	115,090,000	109,980,000	110,911,000	104,206,000	106,579,000	106,007,000	94,662,000	104,900,000
Russia[2]	15,401,771	18,130,230	17,953,812	18,580,752	17,183,259	16,663,000[1]	17,600,000[1]	16,923,000[1]	17,600,000[1]	17,647,000[1]	13,591,000[1]	15,984,000
Venezuela	14,686,657	14,498,968	16,260,492	16,469,071	17,861,784	17,640,872	17,979,227	17,044,016	17,096,298	15,271,901	13,792,479	16,100,000
Iran[3]	6,329,968	16,353,014	6,752,478	7,213,398	7,313,264	7,198,034	7,075,122	6,821,616	5,999,642	5,895,458	6,048,000[1]	5,900,000
Netherland India	4,348,185	4,553,298	4,464,725	4,708,460	4,672,953	4,586,638	4,766,689	4,626,395	4,671,582	4,245,587	4,235,000[1]	4,350,000
Roumania	4,412,000	4,494,000	4,151,000	4,317,000	4,293,000	4,256,000	4,313,000	4,162,000	4,198,000	4,099,000	3,751,692	4,100,000
Mexico	4,249,838	3,387,950	3,338,311	3,848,587	2,800,868	3,432,101	4,372,808	4,211,293	4,349,415	4,141,977	4,017,000[1]	900,000†
Iraq	2,665,259	2,747,102	2,344,213	2,429,587	2,429,787	2,513,145	2,663,244	2,645,099	2,431,532	2,670,844	2,385,464	2,717,278
Colombia	1,660,469	1,678,580	1,724,173	1,681,799	1,592,592	1,617,433	1,811,759	1,797,625	1,824,956	1,784,638	1,508,487	1,814,774
Peru[4]	1,432,874	1,456,329	1,432,398	1,488,965	1,494,467	1,453,712	1,492,971	1,432,508	1,481,701	1,365,152	1,340,000[1]	1,474,364
Argentina	1,361,540	1,381,485	1,339,940	1,355,420	1,345,513	1,369,767	1,360,000[1]	1,365,000[1]	1,370,000[1]	1,378,000[1]	1,289,000[1]	1,380,000
Trinidad	1,301,260	1,351,198	928,752	1,377,547	1,433,474	1,358,600	1,393,317	1,300,485	1,349,908	1,378,021	1,304,819	1,438,436
Burma[5]	625,937	690,501	638,874	633,401	679,335	701,066	704,736	631,584	640,195	662,000[1]	598,000[1]	650,000
Bahrein[6]	659,557	432,748	684,348	585,917	254,937	662,861	847,988	749,354	805,236	805,800	707,379	737,164
Brunei[7]	363,226	376,191	349,500	353,313	373,760	341,111	351,711	376,487	405,623	409,592	381,052	445,194
Poland	318,360	318,360	310,780	318,360	318,360	310,780	325,940	318,360	325,940	321,264	295,620	318,000
Germany	247,060	245,088	249,434	267,847	279,727	282,155	288,926	272,665	277,551	268,028	257,967	270,000
Canada[8]	188,014	192,845	209,181	241,737	288,934	298,753	342,452	341,517	408,580	457,408	413,158	475,000
Japan[9]	198,898	206,544	200,092	204,710	214,819	205,914	210,228	214,330	211,436	218,594	214,191	215,000
Ecuador	181,352	189,658	182,696	186,175	184,780	178,122	182,053	176,252	178,776	187,525	171,138	191,746
British India[10]	162,699	172,458	181,436	183,468	182,311	173,150	181,089	197,043	210,360	195,000[1]	167,000[1]	200,000
Sarawak[11]	130,481	134,523	131,625	143,445	138,031	134,311	133,684	126,439	131,901	137,497	126,578	137,281
Egypt[12]	89,480	97,077	98,021	99,182	97,818	100,699	97,203	95,082	94,509	91,927	84,974	94,545
France	41,865	42,096	45,445	42,125	43,367	44,000[1]	42,339	42,639	42,368	43,000[1]	38,000[1]	42,000
Austria	8,690	27,510	18,410	18,890	13,860	17,010	18,620	20,850	19,320	25,620	27,000[1]	26,000
Czechoslovakia	9,574	8,824	10,824	11,529	10,125	9,667	10,865	12,297	11,734	11,070	13,715	14,000
Bolivia	8,346	11,591	10,692	12,148	13,509	12,271	10,736	11,751	12,810	10,302	7,128	9,100
Others[1]	20,000	17,600	17,600	17,100	15,700	16,000	18,500	17,600	16,400	18,900	19,300	18,800
Totals	166,082,360	174,106,768	169,841,252	177,510,933	180,620,334	175,557,172	179,506,243	172,039,287	172,644,773	169,748,105	151,447,141	164,902,682

[1] Estimate. [2] Russian Sakhalin included with Russia.
[3] Anglo-Iranian Oil Company Ltd. figures revised—fuel oil returned to ground has been deducted.
[4] International Petroleum Company and Lobitos Oilfields Ltd. figures combined.
† Estimated by competent private sources in Mexico.
[5] Does not include Assam and Punjab, which are listed separately under British India.
[6] Bahrein Petroleum Company Ltd. figures.
[7] British Malayan Petroleum Company Ltd. figures.
[8] Includes natural gasoline production.
[9] Japanese Sakhalin, Taiwan (Formosa) and Hokkaido included with Japan.
[10] Excluding Burma.
[11] Sarawak Oilfields Ltd. figures.
[12] Anglo-Egyptian Oilfields Ltd. figures.

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Average to Mar. 31 1938 (Bbl.)	Daily Average 1937 (Bbl.)	Total to Mar. 31 1938 (Bbl.)	Total 1937 (Bbl.)	Total 1936 (Bbl.)	Total 1935 (Bbl.)	Total 1934 (Bbl.)	Total 1933 (Bbl.)	Total 1932 (Bbl.)
United States	3,395,211	3,500,418	305,569,000	1,277,653,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Russia	524,689	553,305	47,222,000	201,856,661	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela*	501,526	514,182	45,164,380	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran*	199,418	211,992	17,947,642	77,377,001	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India	142,562	148,255	12,830,587	54,112,933	47,961,744	45,307,913	45,107,828	41,234,498	37,988,913
Roumania	132,785	142,948	11,950,692	52,176,000	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	100,655	127,275	9,058,977	46,455,687	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	86,373	83,846	7,773,586	30,603,660	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Colombia	56,755	55,609	5,107,899	20,297,543	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Peru*	46,437	47,827	4,179,416	17,457,024	17,593,059	17,066,555	16,314,381	13,257,318	9,899,432
Argentina	44,967	44,482	4,047,000	16,235,910	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Trinidad*	45,792	42,473	4,121,276	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Burma	21,222	21,279	1,910,000	7,766,487	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Bahrein*	25,004	21,266	2,250,343	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Brunei*	13,731	12,047	1,235,838	4,397,038	3,355,086	3,359,054	2,741,341	2,070,162	1,220,486
Poland	10,387	10,404	934,884	3,797,580	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Germany	8,844	8,625	795,995	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Canada*	14,951	8,026	1,345,566	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Japan	7,197	6,817	647,785	2,487,841	2,403,072	2,294,878	1,872,837	1,504,412	1,683,439
Ecuador*	5,116	5,922	550,409	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
British India	5,244	5,864	562,000	2,141,158	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Sarawak*	4,459	4,535	401,356	1,655,565	1,574,196	1,806,795	1,975,617	2,244,331	2,369,338
Egypt*	3,016	3,187	271,446	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535	1,071,976
France	1,366	1,387	123,000	507,067	534,063	529,664	700,000	786,366	755,146
Austria*	873	631	78,620	231,070	52,311	46,312	29,204	6,020	840
Czechoslovakia*	431	339	38,785	123,474	126,603	136,580	177,797	121,695	126,603
Bolivia*	295	337	26,530	123,123	104,746	163,295	157,875	111,973	41,907
Other countries	633	606	57,000	221,000	198,600	189,200	243,100	273,500	327,900
Total	5,409,939	5,583,884	486,202,012	2,037,985,582	1,798,089,381	1,652,108,535	1,517,213,099	1,438,865,152	1,305,588,503

*Revised by official sources.

30% Storage Requirement Proposed in Sweden

THE deliberations of the committee appointed by the Riksdag in June last year to study ways and means of securing Sweden's supply of fuel-oils in the event of war have now culminated in a series of drastic proposals which will soon be put before the legislative body.

Endowed with a traditionally sanguine view towards the danger of Swedish entanglement in a European conflict, the Riksdag has not previously given the matter of peace-time fuel storage any positive attention. As early as 1934 there was a committee urging the point in the Riksdag, but it won no hearing. Now, and primarily it is said, as a result of the example of such far-seeing countries as Belgium, France, Italy and Portugal, the apathy of the Swedish Parliament has been shaken. The safeguarding of the national fuel supply has become a vital national interest. "Parity in preparedness" is the new slogan.

One of the alarming internal tendencies that has hastened consideration of the whole problem is the simultaneous increase in fuel-oil consumption and the decrease in the relative reserve of that product. Consumption has increased enormously during the past few years, and is now up to about 7,548,000 bbl. annually. Fuel storage facilities have not kept pace with this increase; they have been outstripped to a grave extent. Today Sweden is faced with an ominous shrinkage in its fuel reserve, and it is with an eye to remedying this dangerous situation that the proposals of the committee have been shaped.

The pith and kernel of the Committee's proposals is that all oil companies now importing fuel oils from abroad shall be compelled to keep a reserve on hand amounting to 30 percent of the preceding year's demand. To store this reserve supply the state will provide bomb-proof reservoirs to the extent of 1,258,000 bbl. Valueless unless perfectly safe, they will be blasted out of solid rock and completely protected against air attacks.

Were Sweden to be blockaded during a war, the present practice of importing refined oils might become inimical to the interests of industry and the defence. Different kinds and different quantities of each kind of oil would then be needed, so that supplies of oil stored on the basis of peace-time needs might be found absolutely unfit for the new needs. To meet this expected difficulty, the committee recommends the creation of a domestic refining industry, capable of supplying fuel-oil under widely varying demands.

This new refining industry would, in the beginning, be financed with state funds. While state-financed, it would not, however, be state run. The oil companies now represented in Sweden would be allowed to take over the operation. The exact nature of government participation in the scheme is left somewhat vague in the committee's proposals, but will undoubtedly be thoroughly thrashed out in the coming debate in the Riksdag. Such questions as state participation, economic protection to private refineries, capacity, storage conditions, defence stipulations and many others have proved very complicated and will doubtlessly provoke discussion, not only on economic, but also on political lines.

FIRE FIGHTING

LATEST weapon against fires on tankers is the fog nozzle, originally described in WORLD PETROLEUM for October, 1930.

The system is in use on oilfields and refineries along the Pacific coast, and has now received approval by the U.S. Bureau of Marine Inspection and Navigation.

DEEP WELL CHART

DATA on all the wells drilled in the world to depths exceeding 10,000 ft. is now available in a chart just published by Patterson-Ballagh Corporation—including the Continental well, with details of production casing, etc. Copies of this chart are available from J. C. Ballagh, 1900 East 65th St., Los Angeles, California.

J. C. Ballagh and his deep well chart.

GULF EXPORT PRICES FOR MAJOR OIL PRODUCTS

Products		Apr. 12	Apr. 19	Apr. 26	May 3
		Cents Per Gallon			
GASOLINE:	U.S. Motor	4¾	4¾	4¾	4¾
	64/66-375 E.P.	5	5	5	5
	59 Octane and below	5	5	5	5
	65 Octane and above	5¼	5	5¼	5¼
AVIATION GASOLINE:	Gulf Export in cargo lots	10	10	10	9½
KEROSENE:	44 w.w.	4⅝	4½	4½	4½
	41/43 w.w.	4½	4¼	4⅛	4¼
	41/43 p.w.	4½	4⅛	4⅛	4⅛
GAS OIL:	43 Diesel Index and below	3⅝	3½	3½	3¼
	43/47 Diesel Index	3⅝	3½	3½	3¼
	48/52 Diesel Index	3¾	3⅝	3⅝	3⅝
	53/57 Diesel Index	3⅞	3⅞	3⅞	3¾
		Dollars Per Barrel			
FUEL OIL:	Bunker C	85	80	80	80
	Cargo lots	75	75	75	70
	Diesel oil	1.75	1.75	1.75	1.55
		Cents Per Gallon			
LUBRICATING OIL:	Bright Stock No. 8	23	1½	21½	20½
	Bright Stock No. 6½	22½	21½	21½	21½
	600 Warren E	20½	20½	20½	20½
	600 Unfiltered s.r.	16	15½	15½	15
(New York Export Market)	650 Unfiltered s.r.	18	17½	17½	17
	600 Flash s.r.	18½	17½	17½	17½
	630 Flash s.r.	21½	21½	21	21
	Neutral 200 No. 3	24½	23½	23½	23½
	Neutral 150 No. 3½	22½	21½	21½	21½
(South Texas Export Market)	Red oil 500 No. 5-6	8½	8	8	8
	750	9	8½	8½	8½
	1200	9½	9	9	9
	Pale oil 500	8½	8	8	8
	750	9	8½	8½	8½
	1200	9½	9	9	9
		Dollars Per Barrel			
CRUDE OIL:	East Texas delivered at Gulf for export	1.45	1.45	1.46	1.46

FREIGHT RATES

	Mar. 23		Mar. 30		Apr. 6		Apr. 13		Mar. 16	
	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty
Gulf-U.K./Continent	21/-	21/-	20/-	18/9	19/-	18/3	18/-	17/6	18/-	17/6
Gulf-No. Atlantic	18c	15c	16c	15c	16c	17½c	16c	17½c	16c	17½c

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

GEOLOGY

Oil and Gas Possibilities of the Atlantic Coastal Plain From New Jersey to Florida—Olive C. Postley, before AM. ASSOC. PETROLEUM GEOLOGISTS, New Orleans meeting, March, 1938.

Because of recent interest in oil possibilities in parts of the Atlantic Coastal Plain, especially southern Georgia and Florida, this paper gives a summary of the known general geologic features of states along the Atlantic Coast from New Jersey to Florida and of wells drilled in the region to depths of 1,000 ft. or more. No oil in commercial amounts has been found in the Atlantic Coastal Plain, and the aggregate thickness of the Cretaceous and Tertiary sediments in most parts of it is not sufficient to encourage the hope that oil pools will be found; in fact, wells at several places have encountered basement rocks at rather shallow depths. In southeastern Georgia and southern Florida, however, where only a few deep wells have been drilled, the basement rocks lie at greater depth, and the deeply buried Cretaceous and Tertiary formations are little known. Further drilling will be required to determine their character and to test their oil possibilities.

Oriskany as a Source of Oil in Pennsylvania and Adjacent Areas—Charles R. Fettke in BULL. AM. ASSOC. PETROLEUM GEOLOGISTS, vol. 22 (1938), No. 3, pp. 241-266.

The discoveries of relatively large volumes of gas in the Oriskany sandstone in the Wayne-Dundee field in Schuyler County, New York, in March, 1930, and in the Tioga field in Tioga County, Pennsylvania, in September, 1930, first focused attention on this Lower Devonian formation as a potential source of gas in the northern Appalachian Plateau province. The areal distribution, thickness, and physical characteristics of the Oriskany sandstone are described. Most of the Oriskany gas production in the northern part of the province has come from eight pools located in south-central New York and north-central Pennsylvania. Their location, size, structure, and other pertinent features are described. Oil in commercial quantities in the Oriskany has been encountered in only two small pools in eastern Ohio. A relationship between the composition of the hydrocarbon gases found in the Oriskany and the degree of metamorphism of the associated strata is pointed out.

There is a close relationship between the composition of the hydrocarbon gases in the Oriskany sandstone and the degree of metamorphism of the associated strata. The gas from the Tioga field is dry. It contains 99.5 percent methane and no higher hydrocarbons.

Northwest of the 60 isocarb the Oriskany sand gas wells produce appreciable quantities of distillate and casing-head gasoline. The Beaver County, Pennsylvania, and Columbiana County, Ohio, pools are examples. Farthest from the source of the dynamic forces that caused the metamorphism, a paraffine-base, wax-bearing oil is found in some places in the sandstone.

Judged from the results obtained in north-central Pennsylvania, it does not seem likely that any large reserves of gas in the Oriskany sandstone exist in the prominent foreland folds southeast of the 70-isocarb line. Northwest of that line in south-central New York and north-central Pennsylvania, eight pools that may be considered to be of commercial rank have been opened in the seven years that have elapsed since gas was discovered in the area in commercial quantities. In each of these, structural rather than stratigraphic traps have caused the accumulation of the gas. In view of the large amount of prospecting that has been conducted in the area, much of which has been based on detailed geological surveys, both surface and geophysical, it does not seem probable that any large number of additional pools of the rank of those already developed remain to be discovered.

In northwestern Pennsylvania there is a possibility of commercial production, but because of the probable thinness of the Oriskany sand no large acre yields are to be expected. Much will depend on the discovery of favorable structures. The Oriskany sand possibilities of southwestern Pennsylvania are still practically unexplored.

Application of Numerical Abundance and Faunal Assemblage for Subsurface Correlation—Stanley G. Wissler, before AM. ASSOC. PETROLEUM GEOLOGISTS, New Orleans Meeting, March, 1938.

The Tertiary formations of California are measured in thousands rather than hundreds of feet. Foraminifera are abundant throughout the column, but most species have extensive vertical range, many of them occurring throughout one or more formations. Local paleontologists first attempted to use the principle of first occurrence for well correlation. By this method it was normally impossible to do more than recognize the formation represented. Since the average California well penetrates only two or three formations, it was necessary to develop a method by means of which accurate correlations could be made within the formations. By applying the principle of relative numerical abundance and faunal assemblage and sequence to long ranging species, the author has been able to establish a great number of marker zones and horizons. For example, the Repetto formation (Lower Pliocene of the Los Angeles Basin) has been subdivided into 19 zones with 75 subzones and horizons. By means of this routine, well correlations, accurate to the foot, are made. Minor variations in faunal sequence and abundance are such that further subdivision is not only readily possible, but in many cases limited only by the fact that each sample used normally represents a three-foot interval. Similar zones have been established for all of the marine formations present in the chief oil-producing areas of California.

GEOPHYSICS

A Test of Petrographic Correlation of Oil Sands in the Gulf Coast—R. Dana Russel and Leo W. Hough, before SOC. ECONOMIC GEOPHYSICISTS, New Orleans meeting, March, 1938.

The writers were furnished with 24 sand samples from the Bosco field and told to correlate them. (Positive correlation of the samples, based both on Schlumberger data and paleontology, had been made previously by the Superior Oil Co., but this information was withheld). The samples were identified only by number, and no information was furnished except that six sands were represented. The test, therefore, was made particularly difficult by the lack of any information on the relative depths of the sands or the number and spacing of the wells from which they were secured, the relatively small number of samples from each sand, and the fact that the samples proved to be very similar both mineralogically and physically. Study of the data from the analyses, however, resulted in the correct classification of the samples into four groups, two of which included two adjacent sands. This would appear to be a clear demonstration of the value of petrographic methods in subsurface correlation, especially in view of the rigorous conditions of the test.

(Conversely, it is a demonstration of value of electric logging and paleontology in correlations, and emphasizes the advantage of making assurance doubly sure by using all available helps in the difficult problem of seeing under ground.—Ed.)

Geology of Tepetate Field, Acadia Parish, Louisiana—Max Bornhauser and Fred W. Bates, in BULL. AM. ASSOC. PETROLEUM GEOLOGISTS, vol. 22 (1938), No. 3, pp. 285-305 (15 figures).

The discovery and development of the Tepetate field, located in the Gulf Coast area of Louisiana is credited solely to geophysics and might be regarded, in a sense, as a victory of seismographic over travimetric exploration.

The presence of a structure was first indicated in 1930 by a reconnaissance torsion-balance survey conducted by the Tepetate Oil Company (after which company the field was named). Although considerable work was done at this time, no leases were taken until 1933, at which time the same company reworked the area and located a prominent gravity minimum. A lease block was then assembled covering the newly discovered prospect.

The area was detailed in October and November, 1933, by a consulting reflection-seismograph crew, but this work seemed to place the structure considerably south of the torsion-balance picture. The Tepetate Oil Company preferred to credit the torsion-balance location, dropped this southern acreage and leased the present block to the Continental Oil Company for development. The Continental Oil Company reflection-seismograph crew surveyed the block in detail, employing entirely the dip-

shooting method. This survey indicated the presence of a domal structure of about 400 feet of closure.

The discovery well was located accordingly, followed by 60 additional wells, only four of which have been completed as dry holes. A spacing program of one well to every 20 acres (660 by 1,320 ft.) has been adopted and rigidly adhered to.

The producing sand, encountered at an average depth of 8,300 ft., occurs in the lower Marginulina zone. This zone has been assigned to the Middle Oligocene, but more recently considered to be of lower Miocene age. The Tepetate field is a deep-seated salt-dome structure, with at least 250 ft. of closure at the producing level. No faults have been found crossing the field proper; however, faults with considerable displacement were established north and east of the field, thus indicating that the present outline of the dome may be only a part of a much larger structure. The productive area embraces approximately 1,200 acres.

DRILLING

Direct Drive of Rotary Tables—C. H. S. Tupholme, in PETROLEUM TIMES, vol. 39 (1938), No. 1000, p. 324.

A direct-drive engine of British design is built to work with steam at temperatures up to 600 deg. F. and pressures up to 350 lb. It develops 300 h.p. at 1,000 r.p.m., with 300 lb. per sq. in. steam pressure. The construction and the operating principle are simple. The essential parts are the main cylinder, the rotor and the two abutments. The only other parts are the two heads, or end plates, and some timing gears and bearings.

In operation, steam is admitted to the cylinder, which also forms the body of the engine, and conducted through slots into the heads. From the heads, the steam passes through annular openings, which align with similar openings in the rotor. The length of these annular openings controls the points of admission and cut-off. The arrangement of the blades of the rotor and the annular openings is such that there is no dead centre. The steam exhausts through ports in the cylinder wall just under the abutments whence it is conducted to the exhaust manifold. Unlike a turbine, this rotary engine has high starting torque and yet may be operated at relatively high rotative speeds.

In view of the high temperature of operation (550 deg. F.) the cylinder, rotor and abutments are cast from a nickel-molybdenum cast iron to prevent change of clearance from growth of the iron.

Chemical Treatment of Trinidad Drilling Fluid—I. McCallum, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 24 (1938), No. 171, pp. 1-15.

Apart from density, the three physical characteristics of drilling fluid which are of paramount importance in assessing its value in practice are viscosity, gel strength and its ability to form a mud sheath. For the experiments described two basic forest clay muds of 80 and 85 lb. per cu. ft. loaded with barytes to 110 lb. per cu. ft. were used, and the relative effect on viscosity and gel strength of sodium silicate solution and quebracho/caustic soda solution was investigated. Not only was the quebracho solution shown to be superior in reducing the viscosity of the mud, but it was also found that considerable over-dosage of quebracho can take place without the mud acquiring a high gelling rate. The silicate-treated muds, on the other hand, rapidly developed dangerously high gel strengths once the optimum point had been passed. Experiments were also carried out to investigate the gelling effect produced by cements in drilling fluid, and methods of overcoming this effect. It was shown that cement had the power of cancelling the viscosity-reducing properties of silicate, whilst quebracho successfully lowered the viscosity to its normal value. Two other chemicals, sodium tannate and sodium gallate, were found to be, if anything, better than the quebracho in this respect, but in the absence of cements their action was considerably less.

Search for New Oil Pools with Portable Machines—L. G. E. Bignell, in OIL AND GAS JOUR., vol. 36 (1938), No. 44, pp. 44-45.

This paper carries the suggestion that much territory is ripe for exploration with the core drill. One such area is the fringe around regional uplifts where known gas and oilfields lie near the crest of the structures. The other is undeveloped territory about which much of a general geologic nature is already known on the basin side of uplifts, ancient mountain ranges adjacent to old seas which provide ideal conditions for the deposition of sediments and formation of stratigraphic traps which are hard to locate by geophysics, and where core holes will be a worthwhile guide.

This suggestion gains pertinence from the fact that portable rigs for cable tool coring to depths of 4,000 ft. are now available at relatively small cost. One such outfit developed is on record as capable of drilling a 6¼-in. hole for $2 per ft., all costs included. Several such units are said to be working in the Mid-Continent area.

With the equivalent available for exploration of likely areas it is expected that the future course of oil companies will be to do much of this type of work instead of drilling wells with the sole purpose of striking oil. In the long run such work will not be very costly and money so spent will at least add very materially to the knowledge of the regions explored and in time will lead to the discovery of new oilfields of importance.

Use of Drilling Time in Determining Completion Practices—Max David, before AM. PETROL. INST., Production Div., Ft. Worth meeting, March, 1938.

Drilling time is defined as the time required to drill a certain interval of depth, or the time required to sink the drill one, two, five, or ten feet. Drilling time is noted by marking the required intervals on the kelly, and noting the time elapsed when the marks reach the rotary table. In making these time tests the driller maintains a constant weight on the drill stem (five to six points less than the pick-up weight) and maintains a constant rotary speed of 50 to 60 r.p.m.

The use of the method in the dolomitic limestone reservoirs of the Peruvian Basin (Goldsmith Pool) is described. Comparison of porosity found in cuttings and cores with drilling time reveals that fast drilling time usually conforms to the best porosity. In this particular locality, when the drilling time is more than ten minutes per foot there is little effective porosity; six to ten minutes indicates slight, three to six minutes fair, and less than three minutes very good porosity. This relative classification has been found to work well in the Goldsmith Pool; different but analogous characteristics may be found in other regions.

The method has distinct uses in helping to locate porous zones. It has been possible to locate the top of a pay zone by drilling time alone, but it is of course advisable to take into consideration other checks, as by microscopically examining the cuttings. There is reason to believe that a distinct relationship exists between hardness of the pay section and well potential. Where a high degree of porosity is indicated the ultimate recovery is likely to be in proportion.

Drilling time is self-evidently useful in completion practices, because hard zones suitable for casing landings may be picked out. The well can be stopped on a hard shell or in the top of a porous zone with practically no penetration into this zone. In the first case there may be some protection against the eventual encroachment of bottom water, and in the second case is the probable advantage of recovering all the oil present in the zone down to the next hard shell. Since drilling time is directly correlated with porosity, it gives valuable indications for the control of the subsequent acidizing process, particularly as regards proper rate and pressure of injection in the acid treatment. It is also an indication of the most advantageous shot positions. Useful information is also afforded in such operations as plugback jobs, locating packer seats and liners and in pipe perforations.

Completing Wells by Reverse Circulation in East Texas—F. G. Beckman, in OIL & GAS JOUR., vol. 36 (1938), No. 43, pp. 45-46.

In the usual process of rotary drilling a bit is rotated at the bottom of a hollow drill stem through which the drilling fluid is pumped; the fluid thereupon returns to the surface through the annular space between the drill stem and the wall of the hole, or casing, and in its upward movement eventually sweeps out all the rock cuttings. This is what might be called direct circulation. In reverse circulation the fluid is pumped to the bottom of the well through the annular space and returns upward through the drill stem.

The reason advanced in favor of reversed circulation is that the velocity of the fluid moving in the narrow drill stem is much greater than it is in the more roomy space between the drill stem and the casing. For proper removal of cuttings and debris the velocity of the moving fluid is of more importance than volume. When drilling with low velocities of upward flow the cuttings, especially those of appreciable size, are not carried out of the hole as they are cut, but may accumulate until they have been worked over by the bit into smaller particles and mixed with the drilling fluid to produce mud. When the upward velocity of the fluid is increased the cuttings are carried out rather than floated, and if the velocity is sufficiently high the cuttings are recovered at the surface in practically the same condition as when first chipped off by the bit.

This increased velocity at the same rate of pumping the fluid has two principal results; the cushioning effect of the loosened debris on the drill is reduced, and changes in the characters of the formations are more promptly recognized. There is practically a 100 percent recovery of cuttings; the observer can have in his hands a sample of a new formation within 8 or 10 minutes after the bit has entered it. This is a great help toward accuracy in logging; by controlling the rate of drilling the operator knows what formations he has found or passed through without the necessity of shutting down to obtain this information.

The reverse circulation method is particularly adapted for the use of oil as a circulating medium.

How the World's Deepest Well Was Drilled—A. H. Bell and others, in PETROLEUM WORLD, vol. 35 (1938), No. 3, pp. 33-89.

At latest accounts the Continental Oil Company's well KCL A-2, near Wasco, Calif., had reached a depth of 14,060 ft., which is nearly 1,300 ft. deeper than has ever been drilled before. The experience gained in sinking this hole has revealed much about the problems of deep drilling, particularly as regards equipment performance.

The entire 14,000 ft. was drilled without a twist-off of the drill pipe, which appears to show that the drill pipe now available is suitable for deep drilling.

It has also been demonstrated that for drilling to such depths as 14,000 ft. it is not alone necessary

for manufacturers merely to increase the weight and strength of equipment; it is now necessary to consider a carefully balanced design of the whole equipment. The weight of a string of 3½-in. drill pipe more than 2½ mi. long is enormous, and to handle this weight in and out of the hole will require 10 lines of 1⅛ or 1¼-in. cable. This puts extra requirements on the size and construction of the drum. Elevators and slips require redesigning for extremely heavy loads of drill pipe or casing to prevent crimping of the pipe. It appears probable that present mud pumping equipment can take care of any drilling depths now projected.

In order to prevent the time lost in round trips from making coring impractical at great depths, wire line coring would be most desirable but there are certain obstacles. At great depths the formations are always harder, requiring rock heads which cannot be used satisfactorily in wire line coring. The hole is always reduced at depth so that the drill pipe is too small for satisfactory wire line coring even with drag type heads, and lastly no sand reel is large enough at present to handle 14,000 ft. of ⅝-in. sand line which in turn should probably be 11/16-in. or ¾-in. for sufficient strength.

Running long strings of casing can be solved by the use of six-sheave blocks to take care of loads, but no casing is available that can be run safely as a water string at 14,000 ft. As an example, the latest development in special casing steel gives for 6⅝-in., 29.1-lb. casing a safe setting depth, with a factor of safety of only 1.5, of 12,500 for collapse, and with a factor of safety of 2, a safe depth of 14,800 for tension. It is evident that 5½-in. or 4¾-in. casing will have to be developed for setting at these depths and this in turn will prevent coring below the water string, and it will also make drill pipe, liners and tubing all pretty tight to run through this pipe.

The derrick was a 122-ft. model of 465,000 lb. capacity and had more than sufficient strength to stand the weight.

(This well was brought in April 11th flowing 2,880 bbl. daily from 13,175 ft. Sand thickness was about 75 ft.; 2,890 ft. of liner was bottomed at 14,400 ft., but only upper perforations were open for production test.—ED.)

OPERATION

Pressure-Production Relationship in the East Texas Field—Stuart F. Buckley before AM. PETROL. INST., Div. of Production, Fort Worth meeting, March, 1938.

The rate of decline of the reservoir pressure of the East Texas field was accelerated during 1937, reviving interest in the relation between the reservoir pressure and the rate of withdrawal from the field, and arousing renewed speculation in regard to the possible future behavior of the reservoir. The subject is one of importance not only to the operators, but to the public as well, due to the possible effects of too precipitate a decline of the pressure both upon lifting costs and upon the ultimate recovery of oil.

The majority of the students of the problem have long since recognized that the reservoir energy has been derived principally from a water drive originating in the Woodbine sand. The energy removed from the reservoir by oil withdrawals is continuously replaced by water encroaching from regions of greater pressure farther west. The reservoir pressure, as a measure of the net energy remaining in the reservoir at any time, depends upon the balance maintained between the rate of energy removal in the form of fluid withdrawal and the rate at which energy is supplied by water influx.

The situation readily lends itself to mathematical discussion, because the relation between pressure, time and rate of water influx has been determined, and the effect of water production on the pressure can be calculated. Calculations made on the supposition that the rate of water production might increase during the next two years show that with a daily oil allowable of 500,000 bbls. after April 1st, 1938, the reservoir pressure will decline to 1,030 lb. per sq. in. by January 1st, 1939, and to 870 by January 1st, 1940.

The effect of the water production on the future flowing life of the field is plain. Regardless of the minimum flowing pressure, the rate of pressure decline would be so rapid that substantially no flowing production would be obtained after the first of 1940, at which time the total oil production would be approximately 1,500,000,000 bbl. In the absence of any water production, the reservoir pressure would remain above 1,000 lb. per sq. in. until January, 1946, by which time a total of approximately 2,600,000,000 bbl. of oil would have been produced, or an additional 1,100,000,000 bbl. after January, 1940. If it be assumed that only 65 percent of this additional oil obtained at a pressure above 1,000 lb. per sq. in. would actually flow, there would still be the net loss of having to pump more than 700,000,000 bbl. that could have been produced during the next eight years by natural flow. This loss would result directly from the production during the next two years of a mere 230,000,000 bbl. of water. Every barrel of water produced would therefore exact a sizable economic toll, neglecting entirely the additional costs which would be entailed to dispose of this water.

The magnitude of the possible losses resulting from continued water production should focus the attention of every operator in the field on the problem of its restriction. Whatever remedial measures may be undertaken should be inaugurated before damage to the reservoir has progressed to the point at which it will be irreparable.

Physico-Chemical Properties of Acidizing Solutions and Their Effect on Well Treatment—L. C. Chamberlain and R. F. Boyer, before AMERICAN CHEMICAL SOCIETY, Dallas meeting, April, 1938.

Laboratory and field data are presented to illustrate those chemical and physical properties of acidizing solutions which affect their attack on metallic parts of the well, their flow into and reaction on the porous rock, the formation of emulsions and secondary precipitates, their return from the well, and their subsequent separation from the produced oil.

Special attention is given to reaction rates as applied to determining the distance which acid travels in pores before spending itself, and the resultant shape of the pore after acidizing.

These data, in conjunction with calculations on the optimum distribution of permeability near a well bore, lead to a method for choosing the acid which is most desirable for given field conditions.

Practical Repressuring—Newell M. Wilder, in BULL. AM. ASSOC. PETROLEUM GEOLOGISTS, vol. 22 (1938), No. 2, pp. 189-200.

It is emphasized that the problems of repressuring oil reservoirs are as varied as the natures of the rocks themselves, and sometimes even more so. Information and data obtained from a sand may correspond analytically with those of another or even with those of the same sand in different localities, and yet the difficulties in repressuring the sand are not necessarily solved in the same way; just as a working theory for an individual well may not fit another—even an adjacent well.

One of the most important problems concerned with repressuring work is that of volume and pressure. Questions often asked are: "How much air should be put in the wells?" "How much pressure is needed?" These can not be answered even generally. The sands are not consistent in their makeup as far as repressuring work is concerned. Ordinarily every lease and every field differs from every other. Of course, every different kind of rock would offer different possibilities, and different strategy, especially in the detail part of the work, would be required for the extraction of the oil. It is known that two different sands of the same average permeability will not necessarily take a volume of air or gas at the same pressure, even though the saturation factor is not materially different. In some instances it is surprising to note the difference in pressure required to realize the same purpose.

From this standpoint the author discusses repressuring projects in Lee, Estill and Powell counties in Kentucky. The method of studying these problems is lucidly outlined, with instances of the application of experience in this field. For these reasons the paper is worth consulting.

Three-in-One Oil Wells—I. P. Sanders, in OIL AND GAS JOUR., vol. 36 (1938), No. 47, pp. 39-40.

The practice of producing three oil horizons through the same bore-hole has made its appearance in the Wilmington (Calif.) field. Instances of simtaneous production from two horizons are fairly well known, but the two new Long Beach three-in-one wells constitute a novelty. A special feature of these multiple wells is that each is produced without any mixing. A 2½-in. tube extends down into the lowest producing zone (here the Lower Terminal formation). A packer separates this zone from the productive Upper Terminal, which is produced through a 6⅝-in. casing that surrounds the 2½-in. tube. This horizon is packed off from the overlying productive Ranger Zone, which is produced through a 11¼-in. water string surrounding the 6⅝-in. casing.

Several advantages are seen in this arrangement. In some of the previously existing two-in-one wells no attempt was made to separate the production of the two horizons. With two zones flowing oil through the same string of pipe it is necessary to regulate the combined flow to suit the zone that is most inclined to produce sand; under these conditions the zone less inclined to produce sand is required to produce oil against an unnecessarily high back pressure.

This is not a serious drawback where wells have to be operated under restrictions upon daily production, but a more important advantage of producing each zone through a separate string of pipe is that the new type of completion makes it possible to produce only (or separately) the zone containing the highest gravity oil. The conventional two-in-one wells in this field must mix the Upper and Lower Terminal oils, thereby obtaining a 25-gravity combination. But the new type wells are able to deliver the unmixed Lower Terminal oil, which has a gravity of 28 degrees A.P.I. and is worth nine cents more per bbl. at current prices. The Ranger zone, which is now closed to production by field agreement, can be put on production at a few minutes' notice.

Cleaning Sand From Oklahoma City Wells—G. S. Schuhmacher, in OIL AND GAS JOUR., vol. 36 (1938), No. 47, p. 32.

The combination of extremely low bottom-hole pressure with high productivity in the Wilcox sand zone of the Oklahoma City field has led to production methods which differ from the general practice of attempting to produce wells in such a manner that sand is not produced with the fluid. The Wilcox sand is a very permeable formation found about 6,500 ft. deep at Oklahoma City and had an original bottom-hole pressure of 2,600 lb. per sq. in. The wells flowed naturally in most cases until this pressure declined to 500 pounds and in

several cases wells with 150 lb. or less pressure flowed 2,000 to 3,000 bbl. of oil per day. Large quantities of sand were produced during the natural flow life of most wells. This did considerable damage to surface equipment but it was considered better to flow the sand from the well than to let it settle to bottom and cause expensive and dangerous clean-out jobs.

After natural flow much clean-out work was done with gas lift, which was satisfactory as long as the bottom-hole pressure was high enough to support the column of oil plus sand. When the pressure fell too low for this, an artificial bottom-hole pressure was supplied by the centrifugal pump. Sand troubles were greatly reduced. Instead of new sand trouble every two to four days after a conventional bailing, the centrifugal pump gave 20 days trouble-free operation.

The point which is here emphasized is that the centrifugal oil well pump can be used to pump sand at slow rates of production without too much wear.

Salt Water Disposal—Leo H. Towers, in PETROL. ENG., vol. 9 (1938), No. 6, pp. 52-54.

The disposal of salt water from oil wells in a way that will avoid public nuisance is solved if it can be returned to subsurface sands, again with the proviso that fresh water supplies are not contaminated. Returning salt water to underground sands requires some engineering skill and design. The main problem is to keep open the face of the sand in the return well; that is to say, the returned water must carry no solid substances which might clog the sand pores and thus prevent entrance of the returned water.

A plant which appears to have solved the problem has been installed by the Pure Oil Co. in the Edmond (Okla.) field. The distinguishing feature of this plant is that it is a closed system; in which a main object is to prevent air from coming into contact with the salt water at any time. This exclusion of air is necessary in order that corrosion may be reduced to a minimum (both for the sake of protecting the piping and avoiding formation of products of corrosion which would lodge against the sand face).

The plant as designed has a capacity much greater than is required for disposing of the 500 bbl. of salt water produced daily by the field. The equipment consists mainly of a skimming tank, from the bottom of which the water is pumped through a sand filter and an Aloxite filter. All vessels in which the salt water is handled, from the lease tanks to the mouth of the return well are sealed against air by keeping spaces above the water filled with gas under four ounces pressure.

The well selected for the return was a dry hole with a suitable sand at 2,550-2,585 ft. The hole was prepared by reaming the sand to a diameter of 14 in. The rate of inflow is 1,225 bbl. at 225 lb. and 3,000 bbl. at 450 lb. pressure. The filters are cleaned by back-washing at intervals of 30 to 60 days. Very little attention is required; automatic cut-offs on pumps and engines are provided to divert any overflow into an emergency pond.

Lifting Methods on the Gulf Coast—Neil Williams, in OIL AND GAS JOUR., vol. 36 (1938), No. 43, pp. 42-43.

As the oilfields of the Gulf Coast become older, new problems of winning the oil come to the front. Most of these problems are due to the encroachment of water and the necessity of adjusting production rates to proration regulations. Wells making large volumes of water are likely to be killed if certain minimum rates of production are not maintained. During shutdowns heads of water tend to be build up and it is sometimes necessary to pump for long periods before getting back any oil, and occasionally it is impossible to restore a well to production at all.

In some cases the rate of water encroachment is so rapid that pumping by conventional methods is no longer considered profitable. In a well where production had dropped to one barrel of oil to 1,500 bbl. of water, gas lifting was installed and the total liquid raised per day was increased to 2,000 bbl., of which more than 125 bbl. was oil. Other wells, even some that had been abandoned, were put back on a profitable recovery basis and at the same time the increased oil production brought with it sufficient gas for operation of the system. A substantial increase is expected in the number of wells on gas lift in some fields where it was thought no artificial means of production ever would be needed.

Considerable speculation is arising as to practices to be followed in the artificial production of the ultra-deep wells now being drilled on the Gulf Coast. Oil is being produced at depths below 10,000 ft. and production is steadily being pushed to still lower horizons. So far, no occasion for artificial lifting in any of these deep wells has arisen, as all of the production has been of the high pressure type, and it cannot be determined how applicable any of the present production practices will be.

(Some authorities have expressed the opinion that some of the deep wells of the Gulf Coast have been drilled with small diameters that will render gas lifting impossible.—ED.)

TRANSPORTATION

Application of the Laws of Similitude to the Losses of Head in Pipelines—C. Camichel, P. Willemin and L. Escande, in BULL. ASSOC. FRANCAISE DES TECHNICIENS DU PETROLE, 1938, No. 42, pp. 45-62.

For the transport of gasoline or liquids with kinematic viscosity constants inferior to or but little higher than that of water, it is possible to apply the Darcy formula in calculating the loss of head with distance in a pipe line. The degree of precision is the same in the two cases.

In the case of heavy oil (residues or fuel oils), especially where high viscosities are involved, and where intermediate heating stations are required, the matter becomes complex on account of extreme variations in temperature. Hence the Darcy formula cannot be applied on the principle of similitude. In such cases use may be made of the type formula

$$J^1 = J.\left\{\frac{V^1}{V}\right\}^2$$

where J is the loss of head per unit of length expressed in height of a column of water relative to the flow of water at the average velocity V, where V is such that $V^1 = V\left\{\frac{V_1}{V}\right\}$, the ratio V_1/V being the coefficient of kinematic viscosity of the oil in relation to water. This requires that experiments be made with some standard liquid such as water on representative sections of the line under actual working conditions, using Reynolds numbers inferior to those employed by Darcy.

NATURAL GAS

Necessity for Uniform Spacing of Wells and Ratable Production—A. M. Crowell, in OIL AND GAS JOUR., vol. 36 (1938), No. 45, pp. 42-52.

This paper, by the chief conservation agent of the Arkansas Board of Conservation (formerly chief gas engineer of the Texas Railroad Commission), is an argument for uniform spacing and ratable production of gas wells, irrespective of the volume of flow from any particular well in the field. The proposition is based on the thesis that uniform withdrawal will prolong the life and yield of the whole field, and hence benefit all interests and will conform to the principle of correlative rights.

The geophysical basis of the argument is that in gas sands where the permeability of the sand is not uniform there will nevertheless be a uniform pressure so long as the sand is not disturbed; when several wells are driven to the sand the ones that tap the most permeable portions will produce gas in the largest volume. This will create pressure differentials and an excessive flow toward these openings, to the detriment of pressure in the less permeable sections. The same practical result will occur if an excessive number of wells are drilled on one property. In either case excessive withdrawal of gas from one part of the field leaves the gas in remote or relatively impermeable parts of the field under a diminished pressure, with the eventual result that the abandonment pressure of the field is higher and the total recovery of gas smaller than would otherwise be the case. The remedy is uniform spacing of gas wells and ratable production, allowing no producer to extract more gas than corresponds to his proportionate share of the total reserve. Where such uniform operations are established the time factors in the resistance of the sand to the flow of gas are equalized. In the contrary case large quantities of gas will be left in the reservoir at the abandonment of the field that otherwise could be produced and saved.

These principles have been made the basis of proration orders by the Texas Railroad Commission. There are some producers who do not agree with this interpretation of the doctrine of correlative rights, and the matter is in the courts.

REFINING

Utilization of Refinery Gases—H. Stanley Norman, in OIL AND GAS JOUR., vol. 36 (1938), No. 46, pp. 78-79; 94.

Utilization of gas in its natural state and from refinery stills continued to expand last year and the early part of 1938. One new field was explored on a semi-commercial basis, that of producing aromatics from petroleum gases. Importance of developing aromatics from petroleum gases cannot be overestimated when it is realized that many countries are without coking grades of coal and without gas-manufacturing plants, both of which have been the chief source of aromatics for about 75 years. With the great increase in the production of petroleum and natural gas there has come about a situation which merits exploitation by refiners and chemical concerns. A development plant producing 100 bbl. of aromatics a day is in operation by the Pure Oil Co. and the Alco Products division of the American Locomotive Co. This plant produces distillates showing about 20 percent benzol, 13 percent toluol and seven percent xylol, the remainder consisting of olefines, saturates and other non-aromatics.

The gases are converted into aromatics by thermal polymerization at relatively high temperatures and low pressures. Propylene is the main constituent undergoing transformation; ethylene is converted to a smaller extent, while methane is apparently too refractory for conversion to useful liquid products by thermal means, but may yield to catalysts.

Still another source of aromatics is the by-product liquid produced in the operation of gas-cracking units. When cracking saturate gases such as propane and butane at high temperature there is obtained about 20 percent of an aromatic distillate similar to the aromatic distillate produced by thermal polymerization.

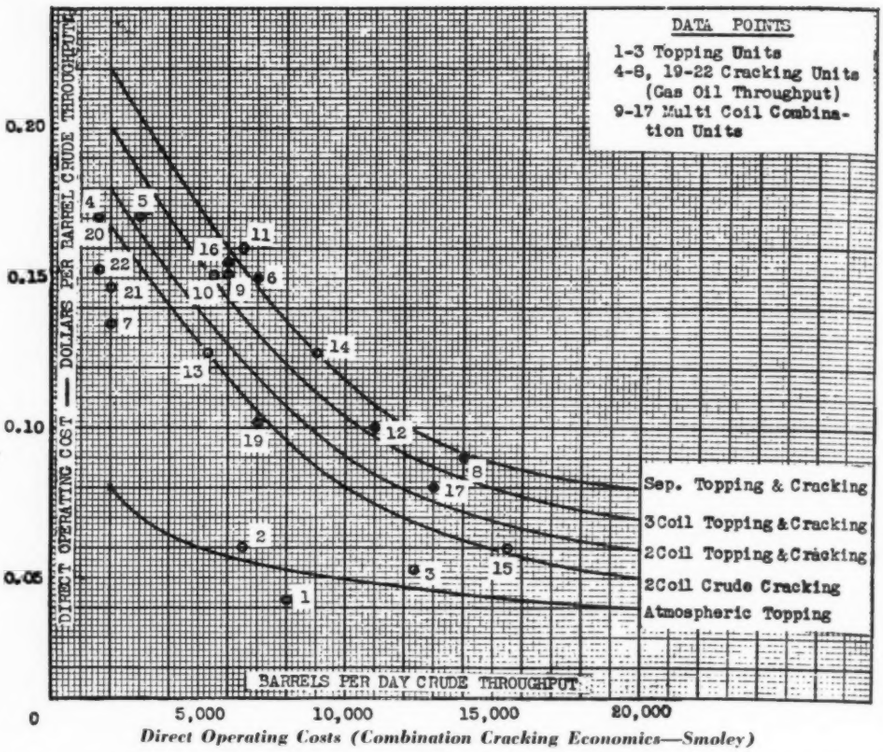
Commercial application of gas polymerization has not only contributed to production of aromatics or gasoline of high-octane blending qualities and reduced the waste of volatile gases, but has gone far toward removing natural limitations of charging

stocks. Crude oils which may have limitations of quantity or quality of gasoline often can be converted into satisfactory charging stock by inclusion of selective cracking and polymerization units in the refinery equipment.

A case in point is the new combination refining unit constructed at La Plata, Argentina, for the Argentine Government Oilfields, (Yacimentos Petroliferos Fiscales). The distillation, cracking, polymerization, and treating phases function as a complete unit in a manner to overcome some of the inherent limitations of the crude available for processing.

The once-through viscosity-breaking operation practiced in the La Plata unit reduces the asphalt to low-viscosity fuel oil with the production of light and heavy gas oil and a minimum percentage of cracked gasoline. Each of these products is then thermally decomposed in a Gyro cracking unit under the optimum temperature and pressure conditions in the light and heavy gas-oil cracking coils respectively.

In order to obtain the maximum octane gasoline from such charging stock, it was necessary to produce a relatively high percentage of gas. The installation therefore included a polymerization plant of the Pure Oil-Alco thermal type so that the entire plant would not be at a disadvantage in respect to relatively high gas fractions consumed in the fuel system or discharged into atmosphere. By charging this gas to the polymerization unit, a blending stock high in octane blending quality is obtained which not only brings up the yield of cracked gasoline but also makes it possible to raise the overall octane value of the finished gasoline.



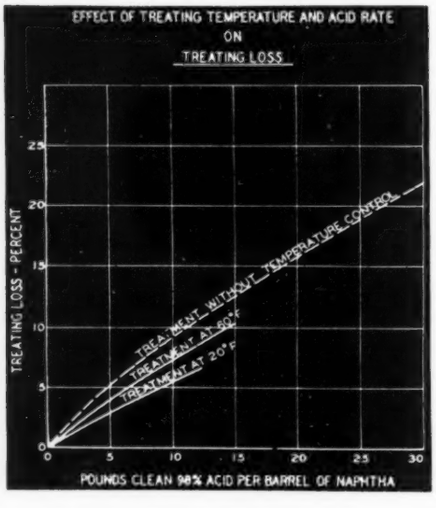
Direct Operating Costs (Combination Cracking Economics—Smoley)

Latest Developments in the Cold-Acid Treatment of Cracked Naphtha—C. W. Stratford, F. G. Graves and E. S. Brown, in REFINER, vol. 17 (1938), No. 3, pp. 109-114; 120.

It is now well known that great economies are possible by the cold-acid treatment of cracked naphthas when desulphurizing high sulphur stocks at a temperature of 20 deg. F.

The advantages of low temperature treatment having been demonstrated as applied to the problem of sulphur reduction, it remained to demonstrate the possibility of effecting a similar improvement in the field of milder-acid treatment where satisfactory color and gum content is of major importance.

The authors here assemble laboratory experiments and other data which show that for this purpose cold-acid treatment can be applied with success over a controlled-temperature range of 20 deg. F. to a maximum of 60 deg. F. The full benefits of controlled temperature treatment can only be obtained under certain definite conditions, which include optimum conditions of mixing (dispersion of acid) and time of contact. In addition, for every specific treating problem there is an optimum treating temperature at which maximum operating economies may be obtained. The influence of temperature on acid rate and treating losses is visualized in the accompanying graph, which also shows that a treating temperature of 20 deg. F. is somewhat more to be preferred than 60 deg. F. The curves of sulphur removal, polymerization loss and octane loss are entirely similar.



The commercial plants now operating by the system make considerable use of automatic control instruments which greatly simplify the matter of chemical control of the process.

Improving Gasoline by Caustic Washing—C. M. Ridgway, in OIL AND GAS JOUR., vol. 36 (1938), No. 46, pp. 83-88; 92-94.

Information available at the present time indicates an appreciable saving in tetraethyl lead can be realized by the removal of sulphur compounds. It is also apparent that caustic soda can be used for the extraction of mercaptans and that the volume, concentration, and temperature of the caustic soda are very important. The amount of mercaptan sulphur that can be removed and the effect of its removal upon the tetraethyl lead response of the gasoline depends upon the type of mercaptans present and the nature of the motor fuel. Hence, the economic advantage of caustic washing gasolines must be determined for each individual stock by evaluating the influence of the above mentioned factors.

Combination Cracking Economics—Eugene R. Smoley, before WESTERN PETROLEUM REFINER'S ASSOCIATION, Hot Springs meeting, April, 1938.

The literature contains much discussion of the technical aspects of modern cracking developments but the economic factors have not received comparable illumination. Current movement to install improved cracking equipment for the production of more and higher-grade gasoline naturally calls for consideration of the economics involved. This requires a study of the prices of crude oil, gasoline and fuel oil, the market requirements and specifications, and the relation of cost of installation to throughput; also operating costs and overhead of all descriptions.

In making such a study that will be applicable in the comparison of any refinery processes or types of equipment the author takes up the cracking of 36.9 A.P.I. Mid-Continent crude with throughputs of 2,000 to 20,000 bbl. daily. Three types of units are considered; two-coil crude cracking, two-coil topping and cracking, and separate topping and cracking.

The general results are pictured in the accompanying diagram. In making this diagram crude oil prices are taken in the range of $1.20 to $1.60 per bbl. delivered, gasoline prices in the range four to seven cents per gallon, gas produced was credited at 50 cents per bbl., and per cent return was calculated on capital expenditure for the unit itself within battery limits, neglecting tankage, utility and auxiliary equipment; normal royalty charges were taken in, a 90 percent service factor was allowed, and all operating costs of whatever description were figured in. The general result is to indicate that the return on the investment increases with throughput and is greater for the two-coil cracking unit than for separate topping and cracking units. In spite of a higher investment the two-coil topping and cracking unit also has a more rapid pay-off than the two-coil crude cracking unit, and the return is still greater when the two-coil combination is operated to produce gasoline of higher octane number.

The supporting data are based on values from twenty-two representative operations in this country. Flow sheets are given and detailed analyses are presented in numerous graphs.

Bauxite as an Adsorbent in Percolation Filtration—R. H. Hubbell, Jr., and R. P. Ferguson, in REFINER, vol. 17 (1938), No. 3, pp. 104-108.

The use of bauxite as an adsorbent medium for the percolation-filtration of lubricating oil stocks has

lately attracted considerable interest, but there still exists a dearth of published data bearing on the subject; what information there is relates chiefly to the treatment of kerosenes, naphthas and other light products. These authors, who are engineers of the Atapulgas Clay Company, have therefore made a series of investigations on the fundamentals of the use of bauxite for lubricating oil decolorization.

One of the outstanding characteristics of bauxite as a filtering clay for the oil industry is that under certain conditions it loses none of its decolorizing efficiency when revivified by burning; the same material may be used over and over again, almost indefinitely. This does away with the problem of disposal of spent adsorbent, makes it unnecessary to segregate different burnings, and increases filter house capacity. Over against this advantage is set a somewhat low decolorizing efficiency in comparison with the improved fullers earth that is now available, although it shows an efficiency 25 percent greater than that of ordinary fullers earth.

Other points in favor of bauxite are the possibility of producing oil of somewhat lower carbon specifications and high yields of light color oils obtained, particularly in petrolatum percolation. In general the decolorizing efficiency varies over a considerable range of products depending on the type of stock to be decolorized. The choice of bauxite in preference to other commercial adsorbents must therefore be made in the light of each refiner's individual problem.

As stated, the most striking characteristic of bauxite is the maintenance of decolorizing efficiency on revivication, but this is only on condition that the burning operation be carefully controlled, because high efficiency depends on low burning temperature.

CHEMISTRY

Proximate Analysis of Gasoline—Charles L. Thomas, Herman S. Bloch, and James Hoekstra, in IND. ENG. CHEM., Analytical Ed., vol. 10 (1938), No. 3, pp. 153-156.

In this method the gasoline is first separated into seven fractions so that the hydrocarbons in each fraction will contain approximately the same number of carbon atoms. Then the olefines in each fraction are determined by the bromate-bromide method; total olefines and aromatics are determined by a single extraction at 0 deg. C. with fuming sulphuric acid containing 25 percent of sulphur trioxide; the naphthene content of the residue from the acid extraction is estimated by its refractive index.

This analytical method is admittedly not rigorously accurate, but it appears to have much to recommend it for comparative purposes until more exact methods are available.

Effect of Paraffin Hydrocarbons on the Determination of Carbon Monoxide—K. A. Kobe and N. R. Dunbar, in OIL & GAS JOUR., vol. 36 (1938), No. 42, p. 59.

The authors have investigated the accuracy of the determination of carbon monoxide by the method of oxidation with iodine pentoxide. They find that hydrogen, when present in an amount less than one percent, does not affect the accuracy of the determination more than this, however, has a slight effect. Nethane has no effect. Ethane and propane in quantities above one percent have a definite effect on the accuracy. Hydrocarbons above propane should be removed in a liquid air trap to insure accuracy.

Reactions of Sulphur Dioxide with Olefins—R. D. Snow and F. E. Frey, in IND. ENG. CHEM., vol. 30 (1938), No. 2, pp. 176-182.

The authors experimented with ethylene, 1-butene, 2-butene, isobutene, 1-pentene, 2-pentene and other olefins, in each case allowing the olefin to react with an equal volume of sulphur dioxide.

Many of the polymers produced by the olefin-sulphur dioxide reaction were found to be thermoplastic resins, and coherent moldings were obtained, in some instances quite colorless and transparent. The resins produced from the 1-olefins vary in steady steps as the molecular weight of the olefin increases from that of ethylene, which has an extremely high softening temperature and is insoluble in practically all organic solvents, to that of 1-decene which is soft and rubbery at ordinary temperatures and is soluble in many organic solvents. The resins of 2-olefins have higher softening points, are less soluble in solvents, and are more resistant to alkalies than are those of the isomeric 1-olefins.

Although the resins are decomposed by heating well above the softening points, there are fairly wide ranges of temperature within which they can be satisfactorily molded under pressure. Propylene resin can be molded in the range 180-200 deg. C., and *n*-butene resins in the range 125-180 deg. C.

Rate of Ethylene Polymerization—F. R. Russell and H. C. Hottel, in IND. ENG. CHEM., vol. 30 (1938), No. 2, pp. 183-189.

The voluminous literature on polymerization of hydrocarbons indicates a primary interest in the character of the products rather than the mechanism or rate of reaction under clearly defined conditions of phase and of absence of catalytic action. Studies of rate and mechanism of uncatalyzed olefin polymerization reactions published to date have been confined solely to ethylene in the gas phase. The present investigation was prompted by the desire to determine how cracking and uncatalyzed polymerization differ as to reaction order and effect of temperature on reaction rate, when the reaction is carried out in a single phase, either gaseous or liquid.

The rate of polymerization of ethylene in the gas phase differs little from the rate of polymerization when dissolved in liquid naphthalene to the same concentration, in spite of the presence in the latter case of 14 molecules of naphthalene for every one of ethylene.

The polymerization in its early stages is a second-order reaction in the gas phase. In the liquid phase (dissolved in naphthalene) the polymerization reaction in its early stages is of an order between second and third.

As polymerization proceeds, the reaction rate does not fall off. It is concluded that secondary reactions occur between ethylene and its polymers. No detectable reaction occurred between the naphthalene and the dissolved ethylene.

Sweet and Sour Gas—Sol Smith and A. M. Crowell, in OIL WEEKLY, vol. 88 (1938), No. 10, pp. 36-48.

The existence of a sweet and a sour gas field in close juxtaposition in the Texas Panhandle and legislation which imposes sharp restrictions on the uses of the two kinds of gas, coupled with the necessity of making a large number of official inspections within short periods of time has made it imperative to find an accurate method of determining total sulphur in natural gas. In view of the presence of mercaptans it became necessary to devise some method of determination that would embrace the following factors:

(1) The selection of a chemical solution which would completely absorb all of the hydrogen sulphide in the natural gas and allow the mercaptans to pass on.

(2) The use of an absorbent which would catch the above separated mercaptans.

(3) Complete absorption of these gases by use of properly designed scrubbing bottles.

After carrying out a number of tests with cadmium sulphate and cadmium chloride in alkaline, neutral, and acid solution, it was found that neutral cadmium sulphate was the best absorbent tried. Cadmium salts were used because of high solubility of the cadmium sulphide formed. Since the mercaptans also have weak acidic properties, the hydrogen ion concentration of the cadmium sulphate solution is now slightly raised by the addition of a few cc. of .1N sulphuric acid, This prevents the mercaptans from being absorbed in the sulphate solution and aids in a complete separation of the two gases.

A .025 N solution of silver nitrate was found very successful in absorbing the mercaptan gas passing over from the first scrubber bottle.

The absorber used is of the Schott type with a Jenafritted-glass disk extending down the inside of the bottle.

PHYSICS

Ostwald-Fenske Viscosimeter in Routine Use—George F. Fitzgerald, in REFINER, vol. 17 (1938) No. 2, pp. 86-87.

The American petroleum industry has been standardized for many years on the Saybolt Universal viscosimeter. Its popularity is based on many useful features such as convenience, rugged construction, and, until recent years, accuracy sufficient for all practical needs. The Engler and Redwood are standard in most European countries but are seldom used in U. S. A. except as applied to exports. Many attempts have been made to introduce new methods based on kinematic units but they met with little or no success.

The defects inherent in the Saybolt instrument: empirical results, temperature drop through the sample, uncorrected falling head, personal equation in stirring, clogging and burring of tips, are well known and proper allowance is usually made for them. Periodic re-checking and re-calibration are provided to compensate for changes in the instrument. It is customary in manufacturing heavy oils to allow a 10 to 20 percent range in the viscosity specifications. This spread made unimportant the effect of normal errors in Saybolt determinations.

Saybolt results obtained under referee conditions with practically zero correction instruments may not differ by more than 0.5 percent, but under normal conditions in the routine laboratory the accuracy is more apt to be plus or minus 1.0 percent. But an error of 1 percent in viscosity will lead to an error of 4 percent in the viscosity index. Obviously such discrepancies are too great for accurate work.

As a substitute the author finds that the Fenske modification of the Ostwald viscosimeter is eminently suited to routine use. It may be readily handled by anyone proficient in operating the Saybolt instrument. It provides the desired accuracy for viscosity index determinations with the speed demanded for control work. By its use V. I. values are soundly based on fundamental units rather than empirical Saybolt seconds. Eventually most petroleum laboratories will measure viscosity in kinematic units but the trade will continue to quote Saybolt seconds.

USE

Influence of Gaseous Electric Discharge on Hydrocarbon Oils—L. J. Berberich, in IND. ENG. CHEM., vol. 30 (1938), No. 3, pp. 280-286.

Petroleum oils used for insulating purposes in the electrical industries are subject to decomposition, which has been traced to the evolution of gas (principally hydrogen) by the ionizing action of high

voltage electric currents. The result is accumulation of pressure which may rupture the protecting coating. The author made a search for addition agents that would reduce the large gas evolution from paraffinic oils which normally possess high oxidation stability. Such agents are found in aromatic compounds, such as benzophenone or amylnaphthalene, or some highly unsaturated solvent extracts. The protective action of these addition agents is supposed to be due to their absorption of the hydrogen evolved from the oil by the electric discharges.

Synthetic Products from Petroleum—Gustav Egloff, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 23 (1937), No. 169, pp. 645-668.

The author reviews the various products that are obtained by manhandling crude petroleum. Prominent among these are of course the products obtained by straight distillation and cracking-gasoline isooctane, lubricating oils, etc., which have direct relations with power production and use. Then there are whole series of products that ar finding other applications, such as various drying oils for the paint industry and hard resins, for which iso-butene is the foundation material. Dehydrogenation operations are resorted to to produce other olefins and acetylene, which have manifold possibilities in organic chemistry. Another wide road to new uses for petroleum has been opened by the discovery that paraffinic hydrocarbons may be alkylated; especially interesting products of this synthesis is a series of synthetic phenols. The cyclization of paraffins gives a great series of products of interest to the dye industry and which heretofore have been obtained only from coal tar. Other chemical substances of wide use that are obtainable from petroleum are ethers, ketones and alcohols. Oxidation of paraffins offers a way to synthesize fatty acids and waxes heretofore obtainable from the vegetable kingdom. Halogenation provides new and valuable substitutes for natural rubber.

The whole of the chemistry involved, shifting and changing the oil industry, has reached a high level, particularly in the past few years. The accelerated improvement rate is geometric rather than arithmetic. Exciting as the achievements of the oil industry have been in the better utilization and conservation of crude oil, one can look forward with assurance that the future will develop many new products which will have social benefits of great value to mankind.

SUBSTITUTES

Gasoline-Alcohol Blends in Internal Combustion Engines—L. C. Lichty and C. W. Phelps, in IND. ENG. CHEM., vol. 30 (1938), No. 2, pp. 222-230.

Based on heating value alone, the value of ethyl alcohol per gallon as a fuel is about two-thirds that of gasoline. Owing to better antiknock characteristics, alcohol can be used in engines with higher compression ratios than can gasoline; this tends to put the two fuels on a more nearly equal basis when each is used in an engine with optimum compression ratio. However, both theory and experiment show that present standard compression ratios would have to be more than doubled when using alcohol, before efficiencies would be reached to offset this difference in energy content per gallon.

Also, it is generally believed that compression ratios for spark-ignition automotive engines will not reach a value much above 8:1 before some of the disadvantages of high compression will offset the gain in power and economy. Thus it appears that present compression ratios for spark-ignition automotive engines will not be doubled. Consequently, alcohol may always be at a disadvantage compared to gasoline as a fuel for internal combustion engine use because of the low heating value of the alcohol, unless it is obtainable at a lower cost than that of gasoline.

Based on present costs, straight ethyl alcohol is at a disadvantage as a motor fuel. Nevertheless, there has been considerable interest in and discussion of possible use of small amounts blended with gasoline. The object of the tests reported here was to obtain data on the relative performance of gasoline and gasoline-ethyl alcohol blends as fuels under comparable conditions of internal combustion engine operation.

Applying the multicylinder power and fuel consumption data to motor vehicles on the highway (i. e., based on the same power output and with adjustment to maximum power or maximum economy air-fuel ratios for each fuel), the substitution of alcohol blends for gasoline should result in an increase in volumetric fuel consumption of about five and seven percent with comparable mixture ratios for the 10 and 20 precent blends, respectively. Using air-fuel ratios equal to or richer than maximum power for gasoline and without adjustment of air-fuel ratio on substitution of the 10 and 20 percent blends a decrease in volumetric fuel consumption of about two and three percent, respectively, should be obtained. Lowest fuel consumption can be obtained with gasoline, rather than alcohol blends, by adjusting the carburetor for maximum economy mixture.

Based on fuel consumption, ethyl alcohol should cost less than gasoline to warrant its use in 10 and 20 percent blends in engines with optimum compression ratios for present standard gasolines; it should cost about the same as standard gasoline if both the blend and the gasoline are used in engines with optimum compression ratios suitable for each of the fuels; and the blends should cost less than gasoline with sufficient tetraethyl lead to permit operation in engines with optimum compression ratios for the blends.

ECONOMICS

An Equilibrium Theory of Proration—Joseph E. Pogue, before AM. INST. MINING AND METALLURGICAL ENGINEERS, New York meeting, February, 1938.

So far as concerns the oil business equilibrium is defined as a state of balance between supply and demand as affected by numerous factors such as costs, price, profit margins, purchasing power and the aspects of petroleum engineering, that are summarized by the term conservation.

In the author's view proration as now established in the oil business does have an equilibrating effect; it is not yet perfect, and the completeness of its ultimate success will depend on whether affirmative answers can be given to the following questions:

Does proration contribute to the efficient utilization of reservoir energy in the production of crude oil? And is this contribution progressing in the direction of neutralizing the effects of the Rule of Capture through the furtherance of collective action in the single oil pool?

Does proration induce a balancing of supply and demand, without in so doing creating other maladjustments that will tend to upset this balance? And in bringing about such a balance, does proration leave price free to express natural values and perform properly its functional duties?

Does proration operate to preserve capital equilibrium, so that the proper amount of capital is drawn into the business, but redundant capitalization is avoided?

Is proration making adequate advancement toward bringing about a suitable relation between demand and potential production? Is not much greater progress needed in changing methods of administration so as to retard the drilling of unnecessary wells? Is proper headway being made toward the institution of allocation formulas and well-spacing patterns designed to preserve equilibrium both in the single reservoir and in the economic structure?

Does proration promote sufficient flexibility in trade channels to permit their orderly adjustment to changing requirements, with due regard to relative costs and size of reserves? And are its allocation procedures such as to stimulate orderly development and retard improvident operations?

Is proration approaching adequately the problems lying in the sphere of coordination between the oil-producing states? Is the legal instrument devised for this purpose, the Interstate Oil Compact, meeting its responsibilities with sufficient energy and skill to safeguard this field of operation from attachment by a higher central authority?

Petroleum Stabilization Progress in 1937—Earl Oliver, in MINING AND METALLURGY, vol. 19 (1938), No. 373, p. 31.

A review of stabilization in the petroleum industry during 1937 requires consideration of the meaning of the term. If it means a steady continuation of earning capacity throughout the year, then stabilization may be said to have been reasonably satisfactory. If, on the other hand, it means progress in building a foundation that will give reasonable assurance that satisfactory earning capacity will continue throughout the years immediately ahead, then stabilization in 1937 was not entirely satisfactory. Since stability implies a degree of permanence the second interpretation cannot be disregarded.

A list of events throughout the year that will have an influence on stabilization has been compiled. It is by no means complete, nor has the relative importance of the events been considered, but the list does indicate the course stabilization efforts have taken.

The Connally Act prohibiting movement of hot oil in interstate commerce was extended by Congress for two years from June 16th, 1937.

Congress took affirmative action in making funds available for the U. S. Bureau of Mines to continue monthly demand forecasts.

Congress gave its approval to an extension of the Insterstate Oil Company to September 1st, 1939.

Further application of community drilling and operation programs was made throughout the year—mainly small units throughout Kansas and Oklahoma.

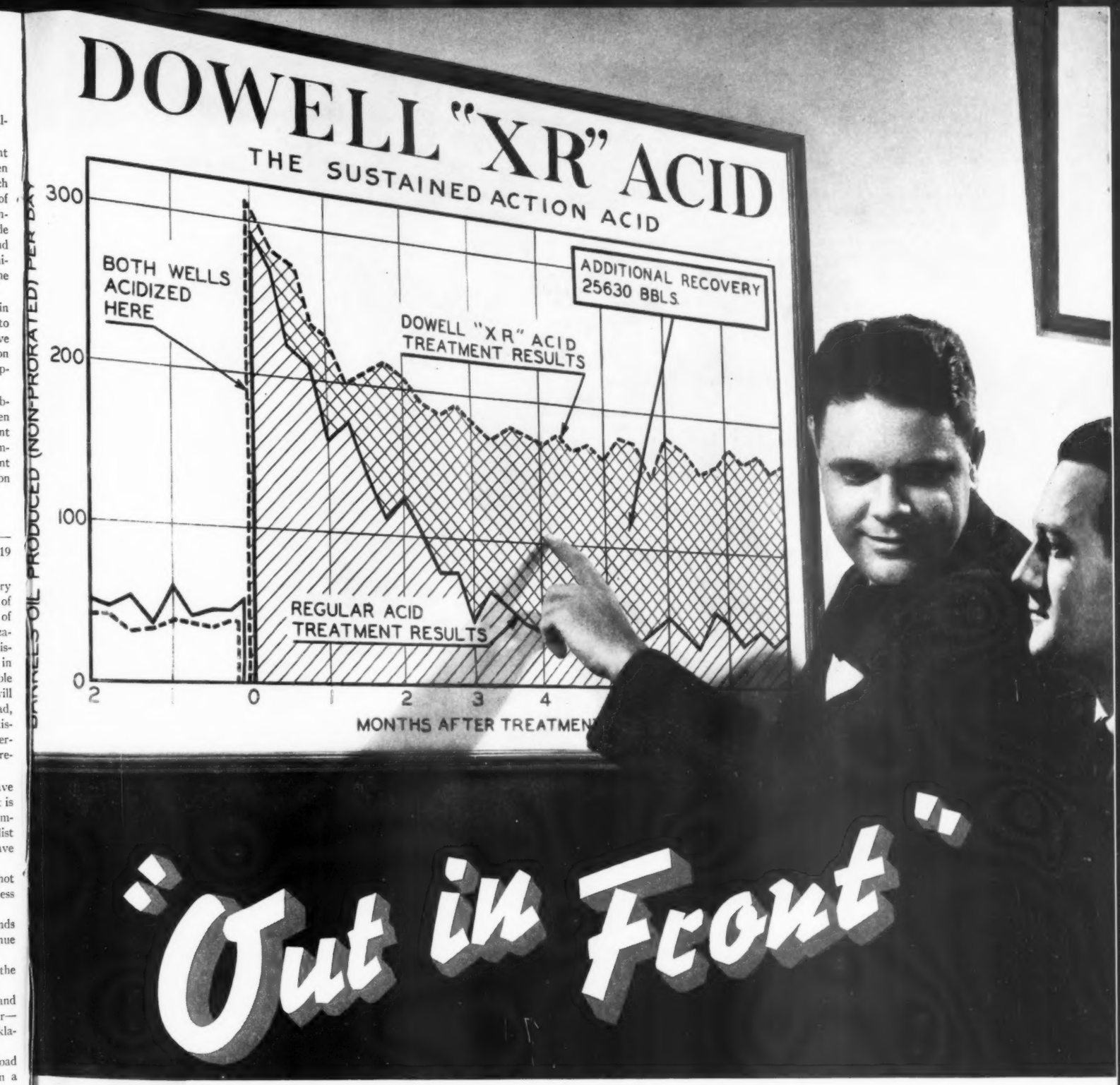
The Supreme Court of Texas upheld the Railroad Commission's power to control well spacing in a given field.

Wider well spacing was adopted in some of the West Texas fields, notably the Goldsmith area where the pattern is one well to twenty acres.

At the end of the year the several State regulatory bodies gave cognizance to the crude oil supply-demand balance.

Some departure from the old rule of capture was made in proration regulations by Louisiana and Texas in their application to specific areas—Rodessa for example—in which recognition is given to the acreage and gas factors in producing a well, thus tending more closely to relate its production to oil in place.

A movement was started by Governor Marland, of Oklahoma, late in November, to promote further



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stabilization in the producing branch through consideration of price. This, apparently, is simply an extension of proration, rather than any corrective to basic legislation.

Certain scattered events throughout the year tend to show steady progress in petroleum engineering concepts. Among these are the organized studies directed toward well spacing by the American Petroleum Institute, the Independent Petroleum Association of America, and other organizations.

The events cited do not constitute a concerted effort to correct the causes of instability. Although the steps taken are not correlated they do indicate improvement in the equipment for attacking the problem, particularly in the determination of demand.

Pennsylvania Grade Crude Oil Price Structure—Sylvain J. Pirson, in OIL WEEKLY, vol. 88 (1938), No. 10, pp. 19-34.

The author makes an extended analysis of price changes in the Pennsylvania grade crude market and finds them not unduly complicated to forecast. An analysis of the supply-demand relation taking into account the potential as well as the storage sources of supply coupled with a study of the tendencies in representative lubricating oil stocks will permit the producer to find out for himself if the planned extension of his producing operations is economically wise. This perhaps would solve the problem of stabilizing the Pennsylvania grade crude markets but would require a degree of economic foresight and determination to put into action the results of logical deduction which it is not possible to expect from a large number of small independent producers. Fortunately they are grouped into associations which could hand them advice as to the outlook for their business, but these can act only in an advisory capacity. It has been the experience of the oil business that effective stabilization may only be obtained by a complicated system of effective as well as flexible regulations.

As to whether proration is possible in the Appalachian field the author believes that a system satisfactory to all could undoubtedly be worked out by which supply and demand could be worked out; this would require close co-operation between producers and refiners.

GENERAL

Pollution of The Air by Diesel Engines—Maurin and Kling, in REV. PETROLIFERE, No. 768 (1938), pp. 49-55.

Fumes given off by some Diesel engines are highly objectionable, and in view of the increase in the number of these engines a question of public hygiene is likely to be raised. The subject has been taken in hand by a French commission on air pollution, and this commission has made a study of various types of Diesel engine with a view of ascertaining the character of the fumes given off by each, and the best means of abating the nuisance.

Analysis of the exhaust gases shows the presence of carbon dioxide and monoxide, water vapor, larger or smaller quantities of solid hydrocarbons poor in hydrogen (soot), unburned gas oil, small amounts of lubricating oil, organic products such as acids and aldehydes, traces of nitric acid and, in the case of gas oils rich in sulphur, larger or smaller quantities of sulphur dioxide and trioxide. In general, the amount of carbon monoxide present in Diesel fumes is much smaller than in the fumes of automobile engines running on gasoline. The odor of Diesel fumes is much less noticeable when the engine is running under surcharge, and when operating at capacity.

Various means were tried to purify the exhaust gases. A certain degree of purification is obtained by bubbling the gas through water, which will remove a large proportion of the impurities. Still better results are obtained by adding to the water some carbonate of soda or lime. Practically complete decoloration and deodorization are obtained by filtering the washed gas through activated carbon; the useful life of such a carbon filter is long and the carbon can be regenerated and used again.

(NOTE. These measures might easily be applied in the case of stationary Diesels. Their application to buses and trucks, which are the chief offenders from the standpoint of public comfort, may not be so easy—Ed.)

Record Output of the World Motor Industry—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 4 (1938), No. 16, pp. 112-113.

According to estimates by the German Statistical Office, world motor vehicle output in 1937 rose by 531,000 units (9.1 percent) to 6,340,000 units, which is a gain of about 30,000 units over 1929 and 4,360,000 units on the depression low of 1932.

However, progress in the leading producing countries was not uniform, and the majority have not yet succeeded in reaching their 1929 output. The United States still leads with 4,810,000 vehicles produced, or 76 percent of the world total, and is thus well ahead of all other countries. American output figures for 1937 were, however, more than 500,000 units below those of 1929, when, it may be recalled, the U. S. A. accounted for no less than 85 percent of total world motor car production. The only leading producing countries which improved their output figures in comparison with 1929 were Great Britain, Germany and Russia.

The following table shows in detail the changes which have taken place in motor vehicle output among the important producers (in 1,000 units):—

MOTOR VEHICAL OUTPUT IN 1936 AND 1937

	Passenger Cars			Good Vehicles			Total Production		
	1937	1936	Change in %	1937	1936	Change in %	1937	1936	Change in %
U. S. A.	3,916.0	3,671.0	+ 6.7	894.0	783.0	+14.2	4,810.0	4,454.0	+ 8.0
Great Britain	389.7	353.7	+ 10.2	118.1	107.6	+ 9.8	507.8	461.3	+10.0
Germany	264.4	244.3	+ 8.2	62.1	57.3	+ 8.4	326.5	301.6	+ 8.3
Canada	155.0	131.3	+ 18.0	50.0	31.0	+61.4	205.0	162.3	+26.3
France	178.0	180.0	— 1.1	22.0	23.0	— 4.3	200.0	203.0	— 1.5
U. S. S. R.	18.0	3.6	+400.0	182.0	133.0	+36.8	200.0	136.0	+46.4
Italy	43.0	36.0	+ 19.4	14.0	12.0	+16.7	57.0	48.0	+18.7

It will be seen from the above table that in the seven countries specified, which account for more than 99.5 percent of world motor car production, the rise in the output of goods vehicles was relatively larger than in the case of passenger cars. This trend is well illustrated by the case of the United States, which is responsible for 66 percent of the world production of lorries and 80 percent of the passenger car output. The number of goods vehicles manufactured last year exceeded the predepression peak by more than 16 percent.

While the share in world motor vehicle production held by the United States continued to decline somewhat, that of Russia and Canada increased.

BOOKS

Ricardo Daniels' Reference Book on Oil Market Companies—Published 1938 by Ricardo Daniels and Co., London, 340 pages (printed for private circulation).

A London view of oil regulation in the United States is put forward in the introduction to Ricardo Daniels' "Reference Book of Oil Market Companies," produced by one of the leading dealers in oil shares on the London Stock Exchange.

As a factor in the share market, the compilers of the Reference Book consider the operation of the inter-state compact to have confirmed its success during 1937.

"As a result of this compact and the close liaison with the Federal Authorities the moment that the recession in trade made its appearance," they state "the already existing machinery was set to work and the necessary adjustments in current production were made towards the latter part of 1937.

"This seems to be a clear proof that the various oil-producing states fully appreciate the importance of balancing supply and demand, and that without so doing prices must be affected. The surprising thing is that oil-producing states such as California and Louisiana still remain outside this compact in view of its stabilizing influence."

As a result of this scheme of co-operation, it is pointed out, oil has been the only commodity not to fall within the vicious circles of wide price movements. When prices were rising it remained cheap to the buyer and adequately profitable to the seller, the ideal position, and a triumph for those responsible for the result.

In the opinion of compilers, the present temporary reverse in trade in many countries is largely due to speculation in commodities on an entirely unprecedented scale by the ordinary public inexperienced in such matters. This speculative demand completely swamped the genuine trader with the natural result that he was driven out of the market and a slowdown quickly followed.

Luckily for the shareholder in oil companies such facilities for speculation in oil as a commodity are not available. Even forward contracts in the industry itself the Reference Book reminds its readers "make allowance for change of world prices, so that speculation is reduced to a minimum".

This book gives detailed information on 28 companies engaged in the petroleum industry; the list is limited to British owned or dominated concerns. Capital structures and holdings are described, balance sheets are presented and opinions are expressed as to future outlooks for the companies. The information is intended to be useful to investors.

Issued "for private circulation only," the Reference Book is obtainable through any London Stock Exchange broker.

Polygot Dictionaries Based on the One-Language System; Technical Press, Ltd., London; 3 vols., Price 6s. each.

Each of the three volumes of this series of dictionaries contains over 8,000 general technical terms met with in the chief and specialized branches of knowledge of international importance, the languages at present covered being English, French and German. Further volumes in other languages are to follow.

The terms are first arranged in alphabetical order and from this a key number is found. In the second part of each volume the terms are arranged in the numerical order of the key numbers. In use, the alphabetical list is consulted to find the key number, and then the numerical list serves to locate the equivalent of the term in a foreign language by reference to the appropriate volume.

The Polyglot Dictionaries will be a valuable adjunct to any technical library.

1. Charging pig iron and steel scrap in open hearth furnaces at steel mill.

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of AXELSON SUCKER RODS FROM PIG IRON TO FINISHED PRODUCT

Nothing is ordinary in the manufacture of Axelson Sucker Rods. From the very beginning at the steel mill, everything is special. Smaller open hearth furnaces and smaller ingot molds of special shape are used. Longer time is required—more passes through the rolls—heavier cropping of ingots, blooms, billets and bars—are specified. Chemical composition, including nine or more elements, is regulated to the hundredth of one percent. Progressive tests and analyses are made and recorded, and if any test is not completely satisfactory, Axelson exercises the right to reject the entire heat—perhaps a hundred tons of good steel, but steel that is not good enough for Axelson.

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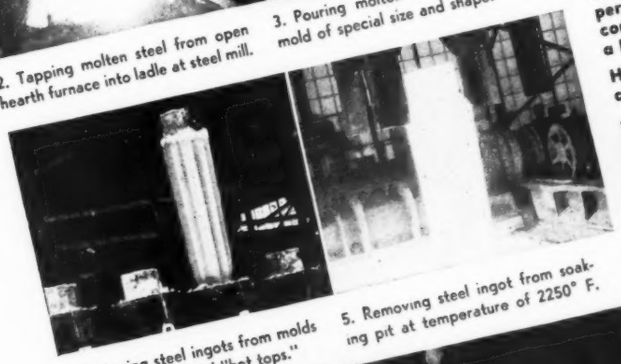
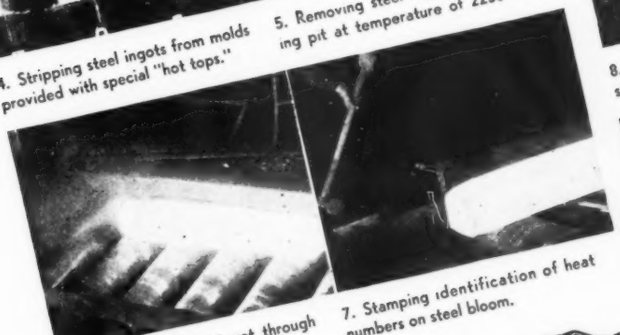
2. Tapping molten steel from open hearth furnace into ladle at steel mill.

3. Pouring molten steel into ingot mold of special size and shape.



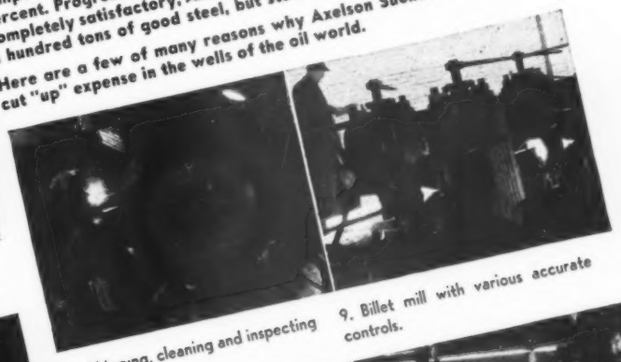
4. Stripping steel ingots from molds provided with special "hot tops."

5. Removing steel ingot from soaking pit at temperature of 2250° F.



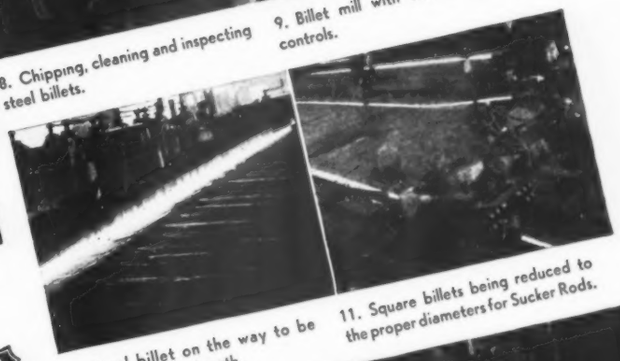
6. First pass of steel ingot through blooming mill rolls.

7. Stamping identification of heat numbers on steel bloom.



8. Chipping, cleaning and inspecting steel billets.

9. Billet mill with various accurate controls.



10. Steel billet on the way to be sheared to proper length.

11. Square billets being reduced to the proper diameters for Sucker Rods.

12. Bars laid out on the "Hot Bed" to cool.

13. Sucker Rod bars being sheared to length.

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Official Figures for Soviet Oil Operations

	Monthly Production (Bbl.)	Daily Average (Bbl.)	Run to Stills (Bbl.)	Drilling (Ft.)
January, 1938	17,647,000	569,258	15,882,000	520,000
February	13,591,000	485,393	13,122,000	320,000
March	15,984,000	515,613	14,842,000	340,000
Jan.-Mar., 1938	47,222,000	524,911	43,846,000	1,180,000
Jan.-Mar., 1937	47,719,130	530,212	43,165,132	1,343,137
Total, 1937	202,856,661	555,772	187,121,389	6,244,660
Total, 1936	199,634,921	545,450	180,582,274	6,958,916
Quota, 1938	244,215,000*	666,066	215,055,000	not available
Quota, 1937	234,450,000	642,329	208,285,000	9,240,000
Quota, 1936	222,345,000	607,000	182,250,000	7,100,000

*Crude oil and gas.

REORGANIZATION

SOVIET oil operations will in the future be controlled from three individual headquarters at Moscow, instead of one as before. Shortly after the All Soviet Union Oil Conference at Baku, Glavneft was reorganized into three units; production, refining, and distribution. Similar divisions were made at Baku and Grozni.

A. Iskanderov, until now head of Glavneft, has become manager of Glavneftpererabotka, the refining division. Manager of production, Glavneftdobitcha, is M. Yevseenko, former chairman of Baku Soviets; while J. Shirokov has been named manager of Glavneftsbit, the division for distribution. F. Popowin has become manager of production at Baku, with E. Bagirow as assistant, and in charge of refining is P. Putchkov. At Grozni, production comes under the management of A. Rokhblatt, while S. Mikhailov controls refining.

Commenting on the recent developments in the Soviet oil industry, INDUSTRIA in its issue of March 27th states that the Baku conference has brought out the sentiments now prevalent in the oil industry. Management is entirely new and consists of young men who were educated by the Communist party and are devoted to their tasks. They have had little experience in organization, so the Commissar for Heavy Industries has issued instructions which are to teach these men how to manage the oil industry. The order to decentralize Glavneft will undoubtedly tend to improve the geological prospecting and drilling operations, while it will also bring a change to production and refining. The decentralization is aimed to increase efficiency by effecting more flexible operation of the refining and producing divisions. The order to increase the yield of light products shows that the present refinery cuts are far from the objective possibilities.

EXPORTS

SOVIET oil exports during 1937 amounted to 1,929,147 tons (14,063,478 bbl.) as against 2,665,309 tons (19,430,103 bbl.) exported during 1936, or a decrease of 27.6 percent, reports the SOVIET JOURNAL OF FOREIGN TRADE. Crude oil exports amounted to 68,552 tons (489,744 bbl.) during the period, as compared with 166,555 tons (1,214,186 bbl.) in the previous year. Total shipments of refined products amounted to 1,860,595 tons (about 14,326,000 bbl.) last year as against 2,498,754 tons (about 19,240,000 bbl.) in 1936. No details were given.

Imports of gasoline from the United States increased from 47,306 tons (402,101 bbl.) in 1936 to 109,657 tons (932,084 bbl.) during 1937.

Soviet exports of petroleum products by way of Istanbul and the Black Sea declined from 308,955 tons in the first two months of 1937 to 75,642 tons in the corresponding period of this year. No kerosene at all has been consigned in 1938 and the drop in shipments of fuel oil is especially great.

Soviet Oil Exports (Tons)

	February		Jan.-Feb.	
Product	1938	1937	1938	1937
Gasoline	.....	36,485	33,553	68,740
Kerosene	.....	14,768	.....	38,176
Fuel Oil	8,242	62,497	14,585	173,551
Lubricating oil	1,893	.....	27,502	28,488
	10,135	113,750	75,640	308,055

Jan.-Feb. 1938

Country	Gasoline	Kerosene	Fuel Oil	Lube. Oil	Total
England	18,153	.....	2,130	7,693	27,976
Spain	15,400	.....	.....	.....	.....
Denmark	.....	.....	.....	11,668	11,668
France	.....	.....	4,842	2,483	7,325
Germany	.....	.....	1,501	5,658	7,159
Italy	.....	.....	6,112	.....	6,112
	33,553	Nil	14,585	27,502	75,640

TRANSPORT

PRAVDA, in the issue of February 14th, 1938, attacks Soviet marine transport for falling behind plan in 1937. "During 1936 and 1937 Narkomvod has acquired 276 new motorships and has increased the capacity of Soviet bottoms by 173,000 tons, yet it does not seem that Russian transport has been improved. This is particularly evidenced by the Caspian and Black Sea tanker fleets. Effective utilization of the

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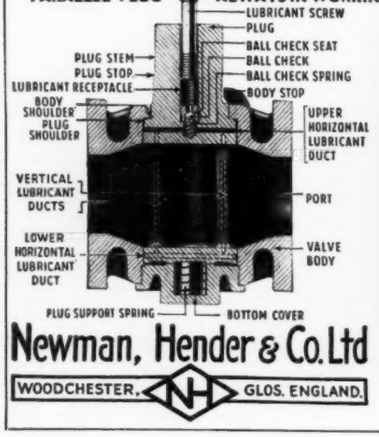

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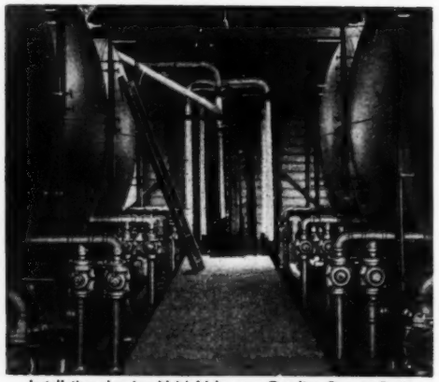

Installation showing N-M Valves on Gasoline Storage Tanks

Caspian fleet fell from 78.5 percent in 1934 to 74.0 percent in 1937. Despite the fact that new tankers have been added each year and that crude oil production rose steadily, sea transport of petroleum from Baku to Astrakhan fell from 6,341,000 tons in 1934 to 6,037,000 tons in 1937. While production increased 320 percent during the past 25 years, Caspian oil transport increased only 25 percent and oil shipments are congesting the railroads.

"Investigations show that these deficiencies are due to inefficiency in repair of ships. Many vessels which had undergone major repairs during the winter recess of navigation again had to undergo repairs during the navigation season. Repairs are of poor quality and are dragged on for years. During the past five years Epron (salvaging organization) has been repairing a number of ships, spending over Rbl. 5,000,000—yet none are ready for service."

OILFIELD NOTES

NO MATERIAL improvement in Soviet oilfield operation is yet visible, and, with the exception of Maikop, no field made par at the beginning of the year. In February, Maikop attained from 115 to 121 percent of plan. Output of this one field is a little more than double that of the production during the corresponding period of a year ago. Although, Artema, Kaganovitch and Kergez (all included under Baku) exceeded plan on individual days, the entire group was from four to seven percent behind its quota during February, 1938. Emba held third place at a range of 91 to 96 percent of plan, while Grozni varied between 84 and 88 percent. Bashkiria had a wide range of 81 to 102 percent, and other fields fluctuated between 58 and 69 percent.

CONFERENCE

A CONFERENCE of Soviet oil operators was held at Baku from February 19th to 25th in which 430 representatives of all divisions were given the opportunity to report present conditions and relate the wrecking and sabotage which had been going on during the past several years. L. Kaganovitch, Commissar for Heavy Industries, opened the session by extolling the progress made by the oil industry during the various Piatiletka periods, but deprecated the fact that large arrears were incurred in 1937 and that 1938 has brought no improvement. He stated that the present shortcomings lie in inefficient organization of drilling and production, while results obtained by the refining division also fall short of the mark.

The assembled representatives, all comparatively youthful, related each in turn the now-familiar story. A serious cave-in

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of 60 wells at Pirsagat (Baku) prevented any progress in production at that field—sabotage. Emba, second only to Baku in extent of deposits, produces annually the equivalent of a week's output by Baku due to inadequacy of roads, difficulties due to environment, and lack of energy—wrecking. Grozni and Bashkiria delegate revealed that ineffective drilling, poor construction of rigs, inefficient operation, and poor management have created arrears—Trotskyists.

The conference was concluded with the expressed hope that quotas will be fulfilled during the balance of 1938 and that whether or not short-comings are due to sabotage they will be overcome. Iskaderv, head of Glavneft, spoke of returning all idle wells to operation during the year, despite the fact that 784 wells were added to the previous 2,300 inactive holes at Baku last year.

REFINERIES

N. KRASILNIKOV, vice-chairman in charge of the refining division of Glavneft, commented in INDUSTRIA of February 20th, 1938, upon the inertia extant in the refining industry. He said that in order to live up to Kaganovitch's demand for an increase in yield of light products to 10.48 percent gasoline and 22.42 percent kerosene by straight-run operations, and to 26.15 percent of gasoline by cracking, it will be necessary to reorganize the refining industry to decrease break downs and losses. Adequate inspection and repairs would in most instances have prevented the many important breakdowns which have been occurring of late. At this point he referred specifically to the aggregate losses of 4,105 hours at Tuapse refinery and 35,225 hours by the eight cracking units at Saratov during 1937, each representing about 50 percent of the total time of operation. He also cited Baku, where no inspections at all were conducted last year; one instance of serious breakdown was due to a burst pipe which had been worn from its original wall thickness of 13 mm. (about a half-inch) to 1.2 mm. and yet was expected to operate under a pressure of 35 to 40 atmospheres. Grozni refineries have a potential four times the quantity which the area produces, necessitating shipment of Baku oil. Grozni refineries are far superior to Baku plants in both equipment and operation, but irregularity of shipments necessitates frequent shut-downs due to lack of crude for processing. Impurities in the oil when it arrives cause damage to the equipment, Krasilnikov also emphasized the fact that losses were incurred by indescriminate blending of entirely different types of crude oils—in many cases high grade crude is mixed with medium and low quality petroleum. J. WEGRIN.

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